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# Good Practices for the Cultivation of Trout in Costa Rica

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**Abstract**

The purpose of our project was to improve production quality and marketing in order to expand the trout farming industry beyond the scope of current expectations through the creation of an all-inclusive reference including uniform practices. We accomplished this by determining the best trout farming practices for Costa Rica which we used to create a comprehensive manual. We provided INCOPESCA with a database containing all the data we collected during the study as well as recommendations to improve their effectiveness in the trout farming industry.

**Acknowledgements**

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**Executive Summary**

The trout farming industry in Costa Rica has existed for less than a century. Rainbow trout were first introduced to Costa Rican waters between the years of 1927 and 1928 for the purposes of sport fishing. In 1954, Costa Rica began importing rainbow trout eggs from Mexico for cultivation. Due to an increase in trout farming popularity, the demands for eggs rose and lead to the importation of eggs from the United States from 1959 to the present (Otarola, 2009).

In 1994, the Costa Rican government created an agency called INCOPESCA to further develop the aquaculture industry. The purpose of this agency is to promote, manage, and coordinate all of the fisheries and aquaculture projects throughout Costa Rica. INCOPESCA aims to achieve conservation, development, and sustainable use of aquaculture resources as well as higher quality standards in the industry. This agency has developed other aquaculture industries significantly; however, the same cannot be said of the trout farming industry (INCOPESCA).

INCOPESCA has had great successes in the tilapia and shrimp industries. Tilapia was introduced to Costa Rica in the 1960's. The farms began as small rural productions, but eventually larger corporations began taking over. One such corporation, known as Aquacorportation Internacional, opened a large farm located in Cañas. Today, this farm is one of the largest commercial tilapia producers in the Americas (Broders, 2005). Shrimp farming production in Costa Rica has been exponentially growing over the past 50 years. Between 1990 and 2003, the total production in metric tons grew by close to 1,700%. These successes were due to an organized set of uniform standards implemented in both industries (Bryand, 2006).

Although the trout farming industry was introduced to Costa Rica earlier than both the tilapia and shrimp industries, it has not been met with the same success. Today, trout farms are generally small-scale family run operations. Most farms cater to the general public by allowing them to fish their own trout and eat it in the restaurant located on the farm. In addition to trout farming, attractions such as lodging and horseback riding generate revenue for the farmers, as well as the trout farming industry, which affects the economy as a whole. A small percentage of farmers sell to local distributors or supermarkets, and they do not export their product.

The goal of our project was to determine the best trout farming practices for Costa Rica and create a comprehensive and easy to understand manual that includes these practices, as well as provide recommendations to INCOPESCA to improve their efforts to develop the industry. We aim to improve production quality and marketing in order to expand the trout farming industry beyond the scope of current expectations through the creation this manual.

We accomplished these goals through interviews and observations conducted at 24 farms throughout the country. As a result of the interviews, we were able to learn the methods farmers use to

manage their farms. We asked qualitative standardized questions on topics such as water properties, filtration, selling, marketing, licensing, the relationships between farmers, and the farmer's relationship with INCOPESCA. The interviews gave us first hand insight into trout farming by further allowing us to understand how and why farmers manage their farms and any difficulties associated with their job. We also learned that the farmers were not aware of the legal aspects associated with operating a farm or of problems occurring on their farms, such as disease and contamination.

To supplement data gathered during interviews, we conducted observational studies during each visit to the farms. Observations were made on topics such as water quality, feed type and storage, trout health, and tank type which gave us firsthand knowledge about how trout farms operate. We were able to identify problems associated with water inflow and outflow techniques, diseased trout, and different methods of feed storage. From these observations, we learned what resources were available to the farmers and how these affect the way in which their farm is operated. By understanding this, we were able to apply their trout farming techniques to the practices outlined in the manual.

From the information collected in our interviews and observations, we created a database for both our own analysis and for INCOPESCA. Within this database we combined the data collected last year with our own. The database included topics such as contact information, sales, trout, licenses, and farm characteristics. This compilation is important because INCOPESCA currently does not have a database of trout farmers due to time constraints and low number of workers. With this database, INCOPESCA will be able to recognize problems occurring on farms and find ways to address these issues. The database also allowed us to analyze data we collected and make conclusions on improvements trout farmers could implement. From this analysis we were able to develop our manual and give recommendations to INCOPESCA.

The manual we created includes good trout farming practices that should be implemented at trout farms in Costa Rica. Our manual is 27 pages long and it will be presented to all 355 trout farmers in Costa Rica as a reference of good practices. We included over 20 sections in the manual, detailing new practices that should be utilized as well as updating existing practices. Some notable sections focused on how to properly market trout to consumers, how to manage feed and information on licensing as well as forms necessary for applying for these licenses.

General farm characteristics that were observed included the surrounding environment and farm upkeep, number of tanks and their type, trout sorting, feed type and storage, protection of fish, and common diseases. From our findings, we discovered that 92% of the farmers interviewed this year rely solely on the farm and its attractions for income to provide for themselves as well as their families. Thus, the success of the farms is of great importance to the livelihoods of the farmers. We also noticed that feeding practices among farmers were very inconsistent. Feed accounts for 50-70% of farm costs meaning

overfeeding can create a significant loss in profits. Additionally, many farmers do not recognize the frequency of disease afflicting their trout. Providing farmers with specific practices for feeding and identification of disease can significantly reduce the severity of these issues.

There are several legal or licensing documents that are required in Costa Rica for all trout farmers, including the Environmental Viability, the Concession of Use and Reuse of Water, the Veterinary Certificate of Operation, and the Water Discharge Fee. These are required to help protect the environment, conserve water, ensure safety of animal products, and manage disposal of waste. Despite the importance for these documents, 62% of trout farmers do not have any of them. By providing farmers with information, licensing forms, and a system of monitoring license status INCOPESCA could increase the amount of farmers complying with Costa Rican requirements.

Information on the topics of farmer experience, techniques for marketing, pricing of the product, and advertising for the farms was also gathered from the interviews. Of the 63 farmers interviewed, 35% reported that they had difficulties marketing their product effectively. This is preventing the industry from reaching its potential. Of the farmers interviewed 46% primarily sell their trout in restaurants, while recreational fishing, supermarkets, and hotels make up the remainder of the markets. We believe that with our manual and our inclusion of information on marketing, trout farmers will start to expand their business a larger audience outside of their immediate area.

Some of the farmers, especially in regions that are difficult to access in the province of San Jose, felt that they did not receive sufficient technical assistance. Farms located in regions with better infrastructure and those located closer to the home of the INCOPESCA technician don Carlos Burantes, were satisfied with the amount of technical assistance they received. However, a small portion of the farmers surveyed this year stated that they only saw the technician when he was delivering fry, and it became evident this caused some negative opinions of INCOPESCA as an organization.

Based on the information gathered from the interviews and observations, we have constructed meaningful recommendations to INCOPESCA on ways to improve their effectiveness in the trout farming industry. We recommend that the agency create a website containing the locations and attractions of the farms in order to reach more tourists. We also recommend that INCOPESCA expand its fry production in order to meet the needs of the farmers. We propose that another technician be hired in order to increase the number of visits made to each farm. In addition, INCOPESCA should create more informative classes for the farmers on topics such as feed manipulation and storage, marketing, and management techniques. Finally, the agency should monitor the licensing of farmers more closely to ensure that they are meeting the legal standards of the country.

With the use and implementation of our database, manual, and recommendations both INCOPESCA and Costa Rican trout farmers will benefit. We feel confident that INCOPESCA will

become more successful in accomplishing their goals with regards to trout farming and that trout farmers throughout Costa Rica will become unified in their practices, facilitating the growth of the industry. Following our set of proper uniform standards will give farmers the opportunity to improve their profits and to expand, allowing the trout industry to reach its full potential.

**Authorship**

This report was written and researched by Danielle Beland, Jonathan Buckley, Laura Miggins, and Allyson Warren. All parts were done in collaboration and are the responsibility of the group.

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## Chapter 1: Introduction

The trout farming industry in Costa Rica is considerably smaller than the thriving tilapia farming industry, but in the past few decades, the trout market has grown exponentially (Ovares, 2005). However, it must significantly improve before it meets the same success as the tilapia market. Trout farms in Costa Rica are generally small family run businesses that aim to attract local tourists and they are not focused on selling or exporting their product to supermarkets or distributors. However, the trout farming industry has the potential to grow and reach these markets, which would increase its profitability.

We worked in conjunction with Instituto Costarricense de Pesca y Agricultura (INCOPESCA) to analyze trout farming practices in Costa Rica, and to identify ways to improve the trout farming industry. This governmental agency was created with the purpose of promoting, managing, and coordinating all of the fisheries and aquaculture of Costa Rica, which is the farming of organisms that live in water, such as fish, algae, and other organisms for commercial sale (Shireman, et al., 1984). Without a governing body overseeing the practices of aquaculture, the environment as well as the industry could suffer. Thus, INCOPESCA attempts to provide standards of practice for the industry that will reduce environmental harm while advancing the development of aquaculture.

Given that INCOPESCA is a young agency, it does not have enough personnel to devote adequate time to all of its sectors. For trout farming in particular, resources and individual guidance are not fully meeting the needs of farmers. References, both print and online, are scarce and do not include comprehensive information. Only one technician provides technical assistance to all 355 farms throughout Costa Rica. A larger work force and more available resources for farmers would allow INCOPESCA to meet its goal as an agency and to better serve the trout farming industry of Costa Rica.

Currently, there are several problems facing the trout farming industry in Costa Rica. One of the main issues is that there are no uniform standards of practice for the trout farmers. This means that areas such as feeding, techniques of aeration, and marketing vary greatly between farms. A uniform set of standards would help to reduce harmful effects on the environment caused by trout farming. Site selection is a large determinate of the success of a farm, and if done properly can decrease the need for deforestation. Choosing a site that requires little clearing

helps to maintain the natural environment and helps to maintain air quality. Proper treatment of water exiting trout farms will help to reduce contaminates carried to the surrounding environment. Adequate disposal of chemicals and wastes from farms also reduces harm to the farm itself and surrounding areas.

There are several legal standards all trout farmers in Costa Rica must comply with in order to help eliminate the harmful effects on the environment. These include the Concession of Use and Reuse of Water License, Environmental Viability License, Water Discharge Fee, and Veterinary Certificate of Operation. A majority of trout farmers do not comply with any of these legal standards; therefore damages to the environment go unchecked. If trout farmers obtained these licenses they would meet environmental and veterinary standards set by Costa Rica while minimizing potential harm on the surrounding environment.

Proper marketing techniques are a main contributor to the profitability of trout farmers. Farmers have a lack of resources informing them of effective techniques for marketing their product. There are limited written materials for farmers to reference as well as a limited number of courses offered to educate them on marketing strategies. These problems have prevented farmers from reaching their full potential to expand to supermarkets and beyond. By providing farmers with uniform standards of practice for both the production and marketing of trout the industry will have the opportunity to reach their potential.

With this study, we have determined the best trout farming practices for Costa Rica. We define best practices as those that meet legal and health standards for Costa Rica while also being environmentally conscious and sustainable. After doing so, we were able to create a comprehensive manual that includes these practices as well as provide recommendations to INCOPESCA to improve their trout farming sector.

## Chapter 2: Literature Review

The trout farming industry in Costa Rica has existed for less than a century. Rainbow trout were first introduced to Costa Rican waters between the years of 1927 and 1928 for the purposes of sport fishing. In 1954, Costa Rica began importing rainbow trout eggs from Mexico for cultivation. Because of the success of trout cultivation for entertainment, farmers began to produce trout for selling purposes. Due to the increase in trout farming popularity, the demands for eggs rose and lead to the importation of eggs from the United States from 1959 to present (Otarola, 2009).

In 1994, the government created an agency called INCOPESCA to further develop the aquaculture industry. The purpose of this agency is to promote, manage, and coordinate all of the fisheries and aquaculture projects throughout Costa Rica. INCOPESCA aims to achieve conservation, development, and sustainable use of aquaculture resources as well as higher quality standards in the industry. This agency has had great success in the tilapia and shrimp sectors, but has not fully developed the trout farming industry (INCOPESCA).

Tilapia was introduced to Costa Rica in the 1960's. The farms began as small rural productions, but eventually larger corporations began taking over. One such corporation, known as Aquacorportation Internacional, opened a large farm located in Cañasand produced canned tilapia Today, this farm is one of the largest commercial tilapia producers in the Americas (Broders, 2005).

Shrimp farming production in Costa Rica has been growing exponentially over the past 50 years. Between 1990 and 2003, the total production in metric tons grew by close to 1,700%. Costa Rica exports around 40% of their farmed shrimp mainly to United States, Spain, and France. These successes are due in part to an organized set of uniform standards implemented in the industry (Bryand, 2006).

Like the tilapia and shrimp industries, cultivating trout in Costa Rica has many benefits. Although trout cost more to produce, they have higher quality meat than other fish cultivated in the region, such as carp and tilapia. The mountainous regions of Costa Rica are not suitable for many other fisheries, however due to the cold water this is the ideal location for trout farming. This allows for the use of a region that would be deemed unsuitable for alternative aquaculture operations (Emerson, 2008).

Although the trout farming industry was introduced to Costa Rica earlier than both the tilapia and shrimp industries, it had not met their same success. Today, trout farms are generally small-scale family run operations. Most farms cater to the general public by allowing them to fish their own trout and eat it in the restaurant located on the farm. In addition to trout farming, attractions such as lodging and horseback riding generate revenue for the farmers. Due to the farmers increased source of disposable income from these other attractions, they become more active consumers of other products and services, improving Costa Rica's economy as a whole.Farmers rarely sell to local distributors or supermarkets, and do not export their product. Farms are run at the farmer's discretion, and do not always meet the environmental and legal standards of the country due to the fact that they have not been forced to. Research indicates that if management, marketing, and environmental standards were implemented the trout industry would have the potential to grow into an industry capable of exportation, following the path of the tilapia and shrimp industries (Emerson, 2008).

A uniform set of standards will address a multitude of obstacles currently existing in the trout farming industry, which include water quality, environmental issues, sanitation, and marketing. Research on trout practices indicates,that the water sources used for trout farming, such as streams, rivers, wells,

and springs, have variable qualities (Fallas, 2009). In order to grow to healthy adulthood, trout require certain water conditions, including set levels for pH, dissolved oxygen content, and temperature. The pH should be between 6.5 and 8.5, and a pH outside of this range cause slow growth rates, gill damage, and death (Klontz, 1991). The dissolved oxygen content must be above 5 mg per liter of water since low oxygen levels can reduce growth rate and cause build up of harmful materials in the tanks leading to infection. While it is generally accepted that trout thrive in temperatures between 12 and 21 °C, temperature is a big factor in trout growing to healthy adulthood and surviving in their environment (Cowx, 2005). Low temperatures cause reduced growth rates and reduce the full size potential of trout, while high temperatures require the farmer to use more feed and allow bacteria to flourish which leads to infection (Lannan, 1986). Also, there is a chance the trout are more susceptible to disease if the temperature is not exact. One disease, Proliferative Kidney Disease (PKD) occurs often when the water temperature is too high. A test done in France found that when the water in a trout re-circulating unit was increased from 14°C to 18.5°C, an outbreak of PKD occurred two months afterward. About 30% of the trout in the tank died from the PKD infection (Noble, 1996).

As with any aquaculture system, there are harmful effects on the environment associated with trout farming. As the water flows through the tanks, it becomes contaminated with uneaten food, fish waste, and chemicals used on the farm. When this water flows back into the source, the contaminants are carried with it. This may negatively affect the organisms living in and around this source (Shireman, 1984). Additionally, the site chosen for a trout farm must be cleared of all trees and vegetation in order to make room for the tanks, equipment, and buildings. This causes deforestation, and since some of these farms are located in the very sensitive cloud forest, it leads to species displacement \ and the disappearance of clouds that define this unique forest (Kaesuk, 2001)

Proper sanitation on the farms is also an area of concern. Incoming and outgoing water should be filtered of large particles and debris, however this is not always practiced on farms. To reduce contamination, tanks should be cleaned when there is more than 30mg of solids per liter of water, and between selling cycles. Suspended materials cause high stress levels, disease, reduced growth rates, and death. Farm personnel should employee proper hygiene and sanitation practices while working on the farm. Using gloves and washing hands between contacts with tanks also reduces contamination (Lannan, 1986 and Francis-Floyd, 2009).

Travel between farms is often difficult due to distance and road conditions, causing negative effects on the profitability of the trout farms. The mountainous terrain containing steep slopes and sharp turns is often difficult to navigate. Roads are either unpaved, rock, or dirt and require travel in vehicles capable of traversing these conditions (Costa Rica Mountain Driving, 2007). These factors complicate the transport of trout from the farm to markets, as well as the travel of visitors to the farms. Additionally,

these road conditions are obstacles for the INCOPESCA technician, making the number of visits he can make to each farm less frequent. These conditions prevent farmers from effectively marketing their trout to consumers outside of their immediate area (Emerson, 2008).

INCOPESCA provides the farmers with a supply of fry, some technical assistance, and limitededucational training. Their trout hatchery was constructed in 1994 and produces 800,000 fry annually. All eggs are purchased from the United States and are scanned for disease to ensure the health of the product before they are shipped to the INCOPESCA. Importing from the United States is the cause for high shipping costs and INCOPESCA only has the resources to provide farmers with fry twice a year.Therefore, farmers often seek other sources of fry due to a limited supply from INCOPESCA. These other sources do not produce the same quality eggs that INCOPESCA purchases, and the deformed or diseased fish that result are unable to be sold, negatively impacting the farm (Personal communication, November 17, 2009).

This agency strives to conduct research and make it available to farmers in the form of literature, however upon interviewing farmers it became evident that very few of them have received any literature from INCOPESCA. Farmers must be made aware of the legal standards that apply to trout farming, including the Environmental Viability, the Concession of Use and Reuse of Water, the Veterinary Certificate of Operation, and the Water Discharge Fee, because without complying with these standards the farm may be shut down at any time, and the farmer may face up to three years in jail (Personal Communication, December 2009). INCOPESCA provides training in the form of courses, meetings, and cooperative programs, however these courses, meetings and programs do not occur on a regular basis, and sometimes do not occur at all within a single year (Personal Communication, November 12, 2009). Courses that last 2-3 days on trout farming basics, proper feeding techniques, and filtration are available to farmers, however they must be requested and very few farmers are aware of their existence. The technician attempts to visit each farm once every two months and touches on the same topics covered in the courses, and also provides personal farming advice. Cooperative programs for the selection of a farm site as well as its construction involve an evaluation of the proposed site by the INCOPESCA technician,, assistance with construction, and follow up to ensure proper management. These programs can last anywhere from one week to two months. However, there is no comprehensive reference for farmers and they must rely on contacting INCOPESCA and visits from the technician. The lack of resources available to the farmers causes them to be more reliant on INCOPESCA, forcing them to call INCOPESCA whenever they have problems. If the farmers had a set of practices to reference, it would decrease the workload of INCOPESCA and also allow the farmers to become more self-sufficient (Emerson, 2008).

## Chapter 3: Methods

We collected information about the Costa Rican trout farming industry to aid in determining the best practices by analyzing current practices through interviewing and observation. Interviewees were chosen by don Alvaro Otarola Fallas in order to allow us to collect data from a variety of different farms, some that were visited frequently and others that were visited less often.

We collected data from the trout farmer's themselves by conducting interviews in Spanish. At the beginning of each interview we informed the farmer of the purpose of our project. The interviews were conducted between the dates of November 10-12th and 17-18$^{th}$ in the provinces of Heredia, Alajuela, Cartago, and San Jose. Figure 1 shows the percentage of farms interviewed within each province.

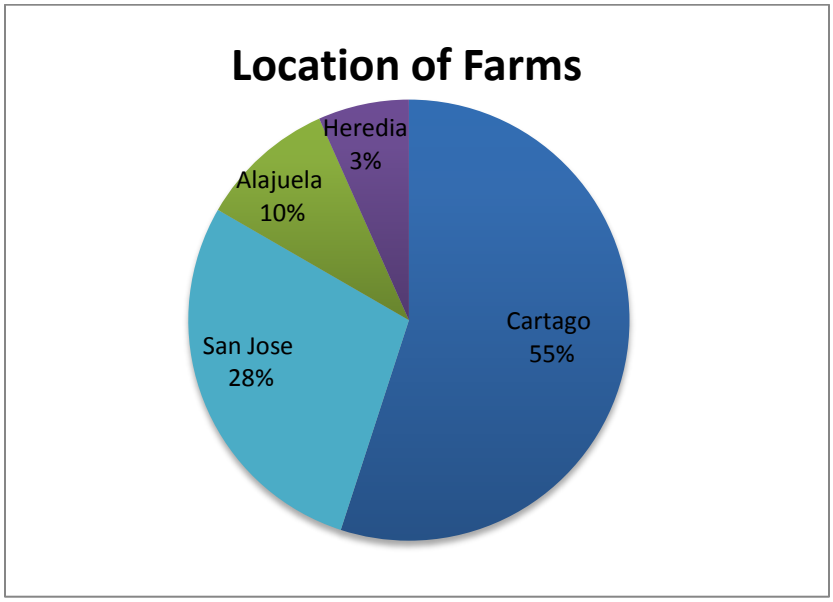


**Figure 1: Percentage of Farms Interviewed within each Province**

We asked qualitative standardized questions on topics such as water properties, filtration, selling, marketing, licensing, the relationships between farmers, and the farmer's relationship with INCOPESCA.

We also recorded evidence of good or poor farm management practices during each visit. Observations were recorded on a previously drafted checklist, and included topics such as water quality, feed type and storage, trout health, and tank type. These observations gave us firsthand knowledge about how trout farms operate and supplemented the information collected in our interviews. We were able to see water inflow and outflow techniques, diseased trout, and different methods of feed storage. From these observations, we wanted to know what resources were available to the farmers and how these affect

the way in which their farm is operated. By understanding this, we were able to identify which trout farming techniques would be possible to implement within Costa Rica to adjust the recommendations made in the manual.

Table 1 details the tasks completed throughout the duration of our project. We formulated and conducted interviews during the first four weeks. Observational studies were conducted during the third and fourth weeks. We began constructing our manual in the second week and continued creating and translating through the sixth week. After completion of our interviews and observations we compiled information into the database and analyzed our data during the fifth and sixth week. Finally, we completed our paper and our presentation during the last week of the term.

| October | November | | | | December | |
|---|---|---|---|---|---|---|
| 25th - 31st | 1st -7th | 8th - 14th | 15th - 21st | 22nd - 28th | 29th - 5th | 6th - 12th |
| Formulate Interview | | | | | | |
| | | Observe Farms | | | | |
| | | Conduct Interviews | | | | |
| | Create Manual | | | | | |
| | | | | Translate Manual | | |
| | | | | Database/Analyze Data | | |
| | Write IQP Paper | | | | | |
| | | | | | | Create and Give Final Presentation |

**Table 1: Project Timeline**

# Chapter 4: Findings

The information obtained through interviews and observations covered multiple topics. General farm characteristics, environmental concerns, licensing among farmers, marketing characteristics, and the relationship between farmers and INCOPESCA were evaluated in our study. Our findings were added to the database created last year, allowing us to analyze the data more accurately. Information on the characteristics of each farm, such as the type and number of tanks, methods of water filtrations, selling, and legal requirements were included in the database. After evaluating the database, we noted critical areas of concern. The interviews gave us first hand insight into trout farming by further allowing us to understand how and why farmers manage their farms and any difficulties associated with their job. The information gained from these interviews and observations allowed us to create a comprehensive manual specific to Costa Rica, as well as to make meaningful recommendations as to how INCOPESCA can improve their trout farming sector.

## 4.1 General Farm Characteristics

General farm characteristics that were observed included the surrounding environment and farm upkeep, number of tanks and their type, trout sorting, feed type and storage, protection of fish, and common diseases.

### 4.1.1 Surrounding Environment and Farm Upkeep

Due to the need for water at cooler temperatures, all of the farms were located at higher altitudes. Steep roads made for difficult travel while the lack of adequately paved roads added to these difficulties. Farms were typically located near a water source such as a river or natural spring. Often there were crops and other animals being raised on or near the farm including cows, chickens, and horses. In general, farms were well maintained. There were a few instances of farms that were either extremely well or poorly maintained. Farms that were very well maintained and landscaped generally were more successful in attracting customers. Poorly maintained farms generally exhibited higher levels of contamination in the water from surrounding plants, animals, and humans than those that were more organized. Keeping a well-maintained farm, with a manicured landscape free of trash and debris with organized clean equipment and proper storage, decreases the risk of possible tank contamination.

### 4.1.2 Tanks

On average, the farms observed were small-scale farms. Figure 2 displays the number of tanks on each farm.

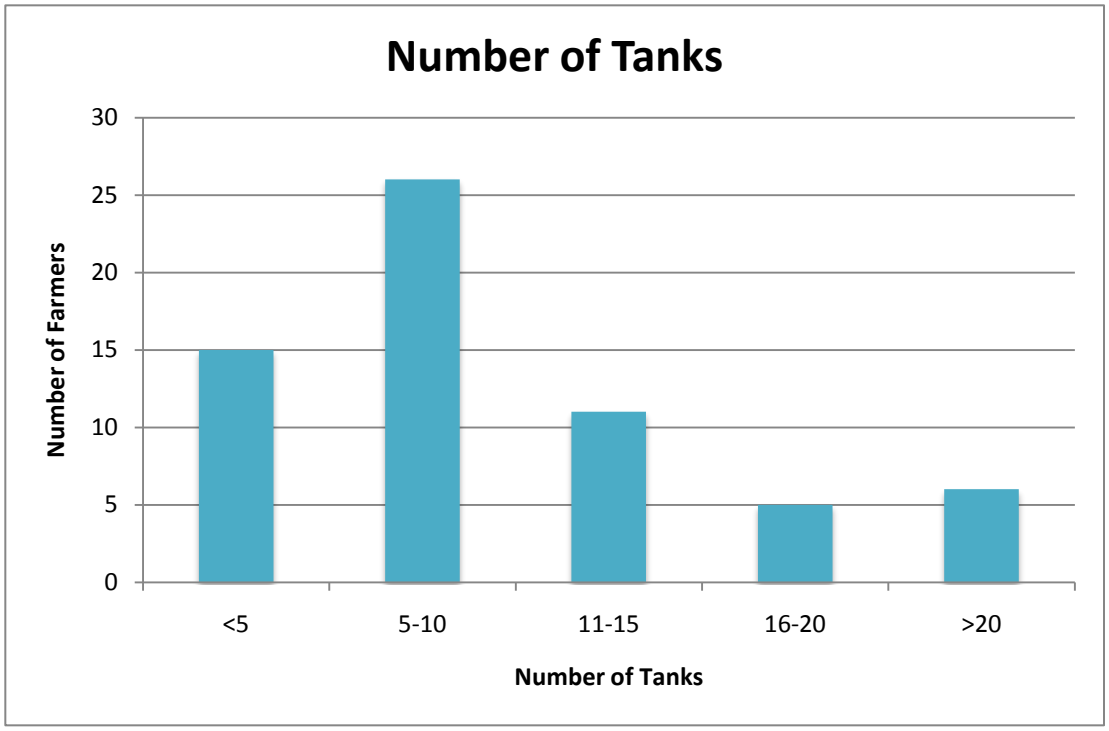


**Figure 2: Number of Tanks Present at Farms Observed**

The majority of farms had between 5 and 10 tanks, and about 15 of the 63 farms observed contained less than 5 tanks. All farms had tanks made of either dirt or concrete and a majority of the farms had both types of tanks. Of these, the smallest fish were generally in the concrete tanks while larger fish were in dirt tanks. Concrete tanks are easier to clean, and on farms that designed their tanks in series, the concrete tanks were the first to receive and utilize water within the series. This ensures a healthy environment, free of contaminates from feed or other fish to allow for proper development and growth. While earthen tanks are more appealing to consumers because they replicate natural setting for fishing, they are more difficult to clean and maintain.

Concrete tanks were either rectangular or circular and earthen tanks varied in shape from rectangular, circular, or irregular. All of the tanks were outdoors and tanks made of dirt were below ground while concrete tanks were both above and below ground. The farmers have been instructed various times that their tanks should be either circular or rectangular, however according to don Carlos Burantes, “We tell them, but they do whatever they think” (Personal Communication, November 10, 2009). Since the farms are located on mountains, many of the farms had tanks at different levels, which facilitated the easy flow of water from one tank to another, and allowed the farmer to utilize gravity, rather than pumps to transport water. Thus, many concrete tanks were partially below and above ground.

On most farms, leaves and fruit from surrounding trees gathered in the tanks, which decreases dissolved oxygen content due to decomposition. There were also a few occurrences of algae and trash in the tanks causing contamination.

### 4.1.3 Sorting

In order to prevent cannibalism, the trout must be sorted by size. Only one farmer used a machine to sort his trout, while everyone else did this by hand. The sorter had adjustable slots in order to separate trout of different size (See Figure 3). Once sorted, trout of the same size are placed in the same tanks, separate from trout of other sizes. All of the farmers successfully sorted their trout.

**Figure 3: Trout Sorter**

### 4.1.4 Feed

All of the farmers hand fed the fish with store-bought food in the form of pellets (See Figure 4). Feed is either stored in the original bags or in sealed barrels. Our findings indicated that bags of feed are usually kept in sheds such as the one depicted in Figure 4, but are not always kept under ideal conditions. We observed feed being stored on the ground, near chemicals, and exposed to the elements. Improper storage on the ground or exposed to the elements leads to deterioration of feed, which decreases the nutritional value of the feed. This increases the quantity of feed needed for the trout to grow into healthy adulthood, which increases feed expenses. Storing feed near chemicals can lead to contamination, which can be harmful to the trout. Feed should be stored in an enclosed shed off of the floor away from any harmful chemicals, moisture, and extreme temperature changes. Since feed represents anywhere between 50-70% of the costs of operating a trout farm, it is essential that feed is storage properly to prevent degradation and contamination.


**Figure 4: Bag of Feed and Feed Storage Shed**

Inadequate feeding of trout is another problem observed on the farms. 18 out of 40 farmers expressed that they would like a course on feed practices. This indicates that many farmers are lacking the knowledge needed to effectively feed their trout to minimize costs while maximizing production. We have included a large section in our manual on how to calculate the appropriate amount of feed based on the temperature of water and the size of the trout in the tank.

### 4.1.5 Protection

A majority of the farms provided no protection against predators in the way of fencing or netting for larger trout. Netting was generally used only on tanks that contained the smallest fish such as the one depicted in Figure 5. A common occurrence was the use of dogs as protection against predators. This is an effective use of protection; however dogs must be kept a considerable distance away from the tanks to prevent contamination of water.

**Figure 5: Netting Used to Protect Trout from Predators**

### 4.1.6 Disease

Disease is a problem on every farm, however many farmers do not recognize the frequency of disease on their farms. While conducting observations, white spots, cuts, frayed fins, and completely black fish were observed. Farmers stated that they identified diseased fish by their color, swollen eyes, or strange behaviors. Most farmers do not treat their diseased fish due to insufficient knowledge of treatments and dosages but some use treatments such as salt baths, oxytetracycline, tetramecine, and formalin. All of the farmers who reported using treatments stated that they did so under the supervision of a professional.

## 4.2 Environmental Characteristics

We also recognized the harmful effects that trout farming can have on the environment and noted any methods of filtration utilized to minimize these effects.

### 4.2.1 Concerns

Although there are many environmental issues associated with trout farming, many farmers are unaware of the impact their industry produces. When asked if the farmers recognized any environmental problems caused by their farms, most farmers stated that there were none. However, other farmers expressed concern regarding deforestation and the increase in temperature of their water sources. In terms of future action, none of the farmers could propose a solution.

### 4.2.2 Filtration

Filtration of both incoming and outgoing water is essential to ensure the water is clean for the trout and also for the environment after being used. As the water passes through the tanks it collects chemicals, food particles, fecal matter, and other contaminants that could be harmful to the environment, animals, and humans. However, most farmers do not filter their water other than through grates to remove

larger debris. Four out of the 63 farms visited treat their incoming water by sedimentation tank. Two farms treated their outgoing water. One used a method of circulating the same water through the tanks and cleaning it after each cycle. Another farm used an evaporation tank to clean the waste left after filtration. Without any filtration, pathogens can enter the tank and cause disease. Also animals living in the surrounding environment can become sick from the contaminated outgoing water. The lack of awareness farmers have regarding environmental issues suggests that they might not have been educated on the harmful effects of contaminated water created through the process of trout farming. Other possibilities include a deficiency in both time and money to invest in filtration, or a development of an apathetic attitude regarding the effects their farms have on the environment.

## 4.3 Compliance with Legal Standards

From the interviews, we determined the frequency of compliance with legal standards among farmers. Farmers must abide by five legal standards in order to legally run their farms. INCOPESCA does not have the authority to amend legal standards set forth by the government. These include the Environmental Viability, the Concession of Use and Reuse of Water, the Veterinary Certificate of Operation, and the Water Discharge Fee. Of the farmers interviewed 62% do not obey these legal standards (See Figure 6).

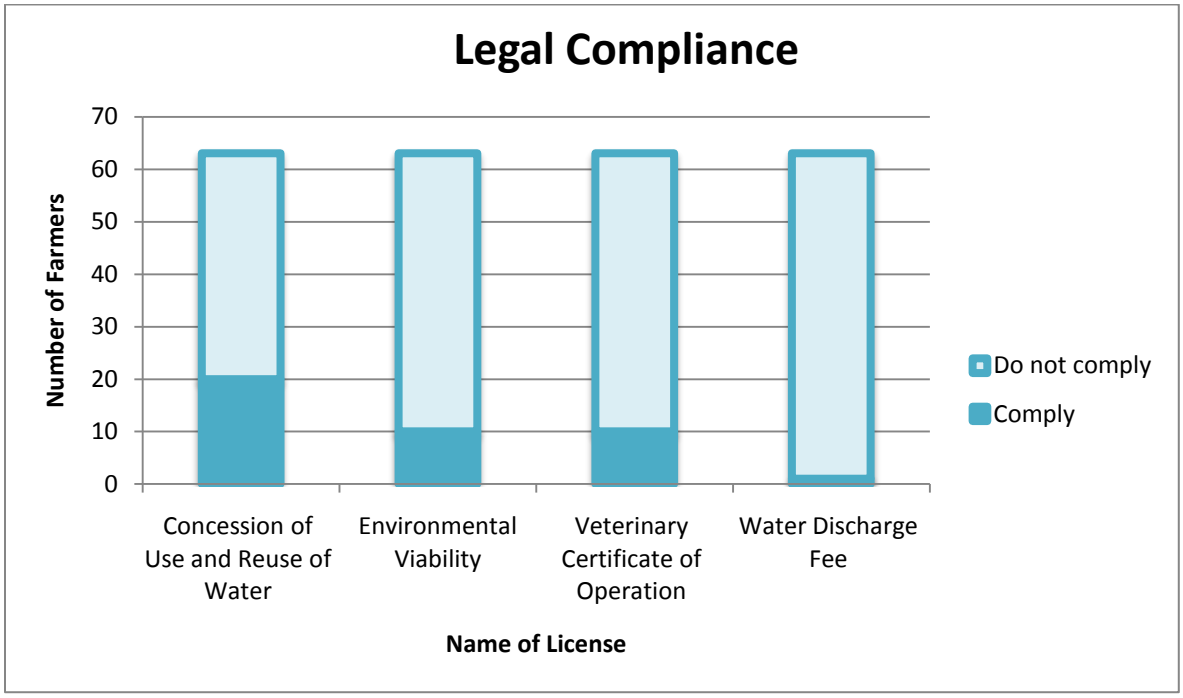


**Figure 6: Number of Farmers that Comply with Legal Standards**

Farmers that complied with three or more legal requirements had an average of 15 tanks, and the largest producer of trout visited had three of the necessary licenses. This indicates that compliance with legal standards will not hinder growth for smaller farms. Furthermore, farmers that complied had an average of

17 years of experience, demonstrating a realization of the need for compliance in order to expand and maintain a successful and profitable farm.

### 4.3.1 The Environmental Viability License

The Environmental Viability license requires that farmers must apply at the National Environmental Technical Secretariat (SETENA). This license assesses the environmental impact of the farm, and may either approve the farm, request modifications, or reject the farm. Consequently, of the farmers interviewed, 84% of the farmers could be having a moderate to severe environmental impact on the surrounding environment and are unaware of it

### 4.3.2 The Concession of Use and Reuse of Water Fee

The Concession of Use and Reuse of Water Fee was established in the General Water Law number 276 by the Ministry of Environment, Energy and Telecommunications (MINAET). It requires the farmers to pay a fee for the use and/or reuse of water since it is a limited resource. This license allows farmers to use the same amount of water in both the wet and dry seasons ensuring that they have a steady supply of water. Of the 63 farmers interviewed, 33 farmers do not have this license because they feel as though it is too expensive. Without this license trout farms will be shut down and farmers can face up to three years of jail time.

### 4.3.3 The Veterinary Certificate of Operation License

The Veterinary Certificate of Operation License was established with the General Law on National Animal Health Service. The National Animal Health Service (SENASA) oversees the implementation of this law, which ensures the safety of products and byproducts of animal origin. When asked about this license most farmers were unaware of its existence. Those that were aware of it believed that having it for one species of animal on the farm would include trout as well, which it does not. As a result, only 16% of interviewees have obtained the license

### 4.3.4 The Water Discharge Fee

The Water Discharge Fee was established by MINAET in order to ensure a healthy and ecologically balanced environment. This law requires that anyone using public bodies of water for disposal of liquid waste must pay a fee. Only one farmer interviewed pays this fee, mostly due to the fact that it was recently reinstated at the end of 2008. This fee is more focused on achieving a social objective, lessening the guilt associated with waste disposal in public water sources, rather than actually achieving environmental consciousness.

## 4.4 Marketing Characteristics

Information on the topics of farmer experience, techniques for marketing, pricing of the product, and advertising for the farms was also provided from the interviews.

### 4.4.1 Markets for Trout

Some farmers expressed having difficulties finding locations to sell their products or marketing their products effectively during interviews. Of the 63 farmers interviewed, 35% reported that they had difficulties such as decreased tourism as a result of the global crisis, lower prices for other types of fish, and preconceived negative opinions regarding the taste of trout. This is preventing the industry from reaching its potential.

Trout farmers have many ways to market their adult trout, but most farmers have restaurants on their farms as a way to sell their trout to customers. Customers can either fish for the trout or simply order it from the restaurant. Figure 7 shows the different markets available to farmers.

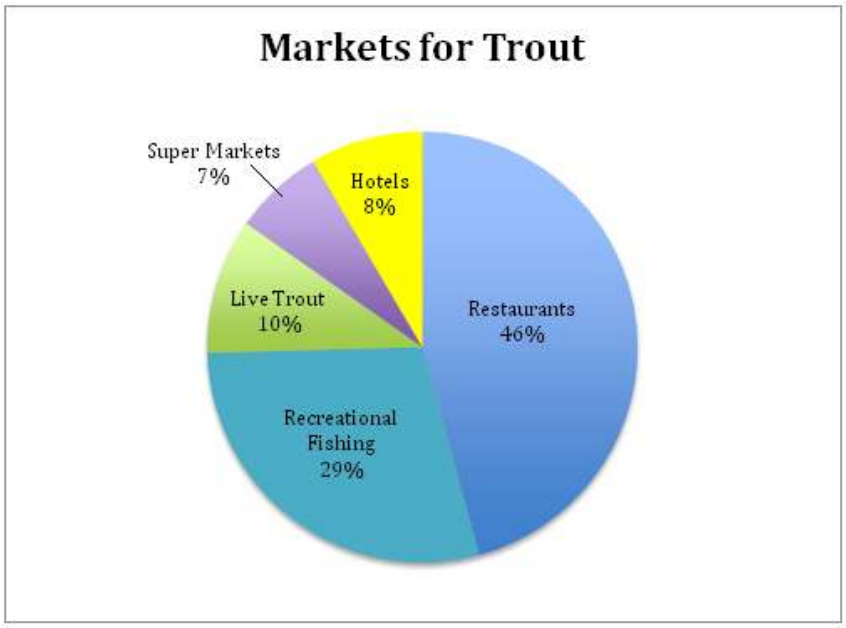


**Figure 7: Percentage of Farmers Selling to Available Markets**

Out of the farmers interviewed 46% primarily sell their trout in restaurants, both on their farm and others. Most of these trout farmers seem to be content selling trout at their restaurants and are not attempting to expand their businesses to distribute their trout to outside sources. Recreational fishing, when farmers allow consumers to pay a fee to fish on their property and keep the trout caught, is utilized by 29% of the farmers interviewed. Only 7% of farmers sell to supermarkets and 8% sell to hotels, but overall farmers do not transport their trout to other locations. We believe that with our manual and our inclusion of information on marketing, as well as how to properly set up a stand to sell trout and how to maintain its quality, trout farmers will start to expand their business outside of their immediate area.

### 4.4.2 Pricing

After gathering data and performing a critical analysis, certain pricing trends were identified. Figure 8 shows that the pricing of the trout is varied among farmers. It is apparent that the prices are relatively standard when we interviewed farmers this year, however many variations did exist when the group interviewed the farmers last year. Last year the highest and lowest prices were 1000 and 5000 colones per kilo, while this year, the highest and lowest prices were 4000 and 1500. Overall the price of trout varied a lot more last year than this year. We cannot comment on the change in price from last year to this year, but we speculate it has something to do with either the drop in tourism, a change in Costa Rican economy in the past year, or it is production costs are not the same throughout each farm, so some farmers must charge more than others.

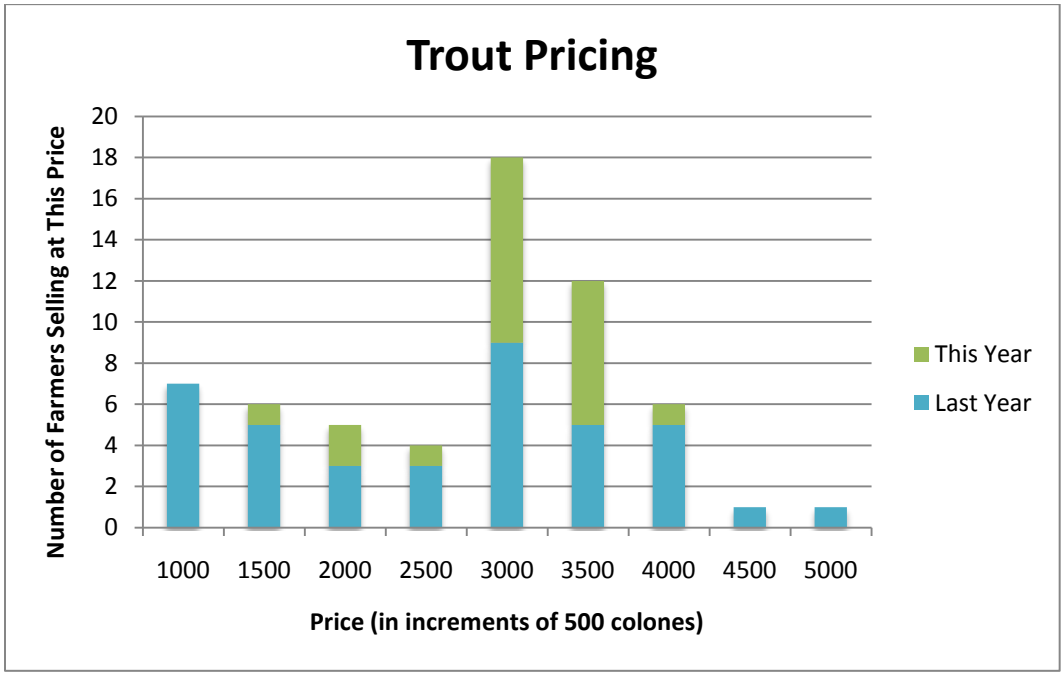


**Figure 8: Price per Kilogram (by 500) Sold by Farmers**

### 4.4.3 Advertising

Currently, most farmers employ limited advertising techniques for the promotion of their business. They rely on word of mouth and roadside signs as their main source of advertising, which can only reach the local audience and leaves great potential for tourists untapped. A majority of these roadside signs were written haphazardly on small pieces of wood, which lacked consumer appeal and effectiveness. The lack of resources and money to reach larger audiences through media such as the internet often leaves farmers with no other options for promoting their businesses.

### 4.4.4 Farming Experience

During the interviews, farmers were asked the number of years of experience they had. Figure 9 displays the years of farming experience cited by the farmers.

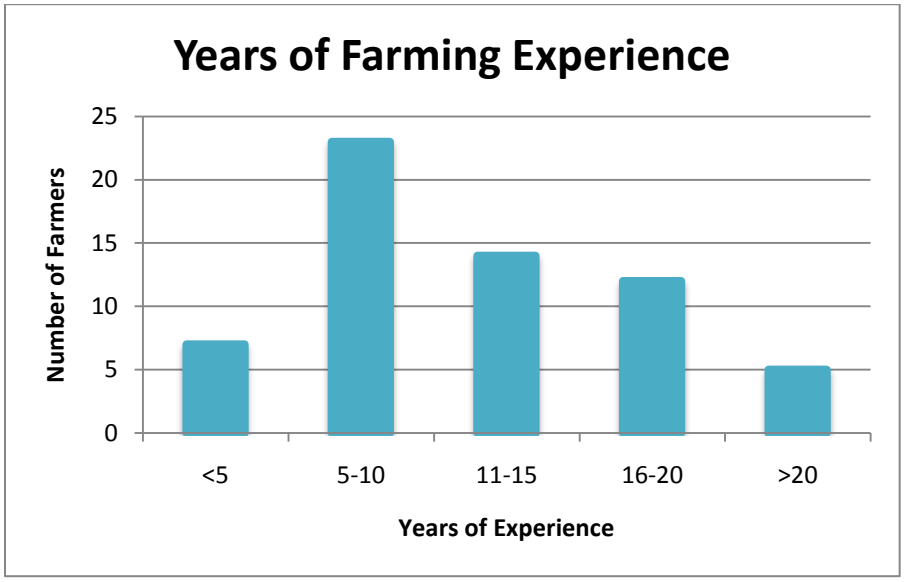


**Figure 9: Number of Years of Experience of Farmers**

The years of experience among farmers ranged from less than a year to greater than 20 years. Most farmers had between 5-10 years of experience, however the average was 12 years. Based on this high average farmers should have made a greater number of visible improvements, such as increased organization of equipment and daily operations, as well as better maintenance of tanks and surrounding environment. Also, since these farms have been in existence for a number of years the lack of compliance with legal standards is alarming. Farmers were also asked the number of workers employed on a daily basis. Many farms only have one or two workers during the week, however the number increased greatly on the weekends to anywhere from six to 16 in response to the increased number of visitors at the farm. Out of the 63 farmers interviewed, 49 had family members working to help manage the farm rather than outside employees. This suggests that the same practices may be perpetuated in future generations. Without any education on new and more efficient techniques, the industry may remain stagnant.

## 4.5 Relationship with INCOPESCA

The relationship between farmers and INCOPESCA was evaluated through interviewing on the specific topics of type and frequency of contact, supply of fry, and any recommendations for improving this relationship.

### 4.5.1 Contact and Communication

Many farmers expressed that when they have problems on their farm, they first contact other nearby farmers to see if they can be of any assistance. If neighboring farmers cannot help, farmers then contact INCOPESCA, which provides them with sufficient assistance. When questioned on the frequency of contact with the INCOPESCA technician, a small portion of the farmers surveyed this year stated that they only saw the technician when he was delivering fry, and it became evident this caused some negative opinions of INCOPESCA as an organization. Many of these farmers were located in regions difficult to access such as those in the province of San Jose. Farms located in regions with better infrastructure, and those located closer to the home of the INCOPESCA technician don Carlos Burantes, were in contact with INCOPESCA with greater regularity and were happy with the amount of technical assistance they received. They reported that they were visited roughly once every two months and at times once per month.

. The majority of farmers responded that they had received assistance from INCOPESCA when selecting their farm location. Additionally, farmers that used treatments for their diseased fish stated that they did so under the supervision of an INCOPESCA professional. None of the farmers expressed any issues with contacting INCOPESCA, and with the exception of one interviewee, all of the farmers classified their relationship with INCOPESCA as either “good” or “very good”.

### 4.5.2 Limited Fry Supply

One issue that was expressed by a few farms visited, both this year and last year, was the lack of a steady supply of fry. Overall, farmers prefer to buy their fry from INCOPESCA because it ensures that they are free of disease and all female, because male trout are more aggressive and territorial and have less body mass.. However, INCOPESCA does not produce fry with enough frequency or in a high enough quantity to satisfy all of the needs of farmers in Costa Rica. Of the farmers interviewed this year and last year, 38 farmers purchased their fry from only

INCOPESCA. Ten of the farmers purchased their fry only from other sources, specifically the Jardin de Dora, Montes de Oro, Carlos Zolando, Miguel Viquez, or the United States. Three trout farmers actually produced their own fry, and 15 farmers purchased fry from both INCOPESCA and other sources: Senor Don Carlos Sorano, Mucho Gaf, Poas, Jorge Acturo Alvanes, de Vial Comacho, Miguel Viquez, the United States, Las Lluvias Truchas Reales, Oscar Games, or their neighbors (See Figure 11).

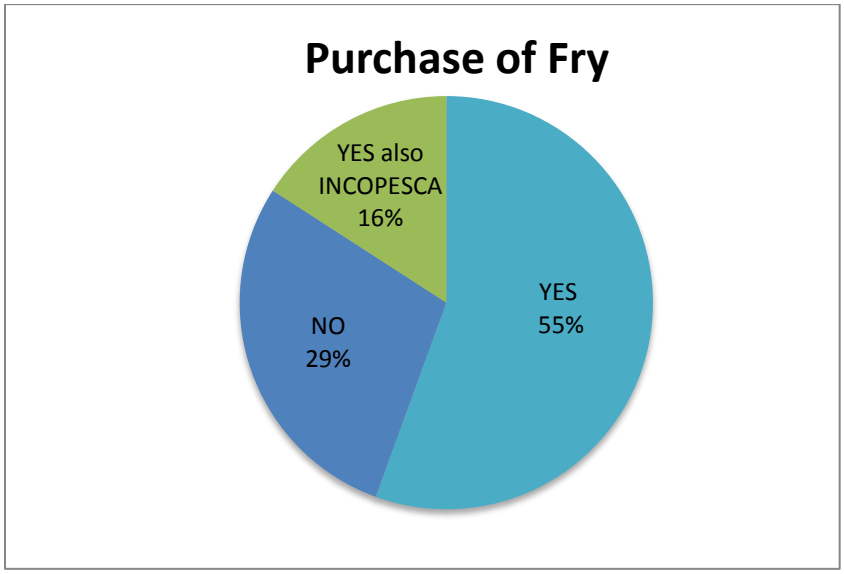


**Figure 10: Percentage of Farmers that Purchase Fry from INCOPESCA**

Some of the farmers interviewed stated that the fry they purchased from other sources sometimes led to deformed or diseased fish. One interviewee stated that some of the fry that she purchased from a source other than INCOPESCA grew to be fish that were bent in half, or that swam on their sides. These fish are unable to be sold and represent a loss for the farm.

### 4.6 Recommendations

After analyzing all of the data collected in our interviews and observations we formulated several recommendations that would help to improve trout farming and Costa Rica as a whole.

#### 4.6.1 Reduce Harmful Effects on the Environment

Research into and action regarding the effects of trout farming on the environment should be enacted in order to prevent permanent damage to the environment.

#### 4.6.2 Providing Education

In our interview we asked the farmers what services they wanted INCOPESCA to provide. A large portion of the farmers requested that INCOPESCA provide more fry, both in

higher quantities and in greater frequency. 11% of the farmers requested more technical assistance, 17% requested more information, and 11% requested assistance with the commercialization and selling of trout. A total of 32% of farmers interviewed requested that INCOPESCA offer more classes, which is represented by the blue section of the graph in Figure 11. When asked what types of programs the farmers would be willing to participate in, the responses included courses on the selling of trout and marketing, the proper use of calcium, feed manipulation, the management of a trout farm, training for employees, and different types of diseases and their treatments. The farmers reported that the major factors that would impede them from participating in a program are the distance from their farm to the location of the course, a lack of time or other obligations, a lack of monetary resources, or a lack of knowledge of the upcoming course. Thus, we recommend that INCOPESCA provide the farmers with classes on these topics in a variety of locations to reach a larger population of farmers at little to no cost to the farmers. In addition, INCOPESCA should send out mailings on a semiannual basis to inform the farmers of the times and locations of the courses offered.

### 4.6.3 Technical Assistance

The farmers informed us that they are not receiving adequate technical assistance. In order to address this problem, we recommend that INCOPESCA hire an additional technician. Farmers would then be visited more frequently giving them more opportunities to improve their farms. It would also allow the current technician to spend more time at each farm he visits.

### 4.6.4 Fry Production

The farmers also expressed a need for more fry. We recommend that INCOPESCA expand its fry production in order to meet the needs of the farmers. INCOPESCA could either construct another fry hatchery or expand their current one. Another potential solution would be to, rather than producing two large quantities of fry per year, produce smaller quantities of fry with greater frequency. This would keep the hatchery running continuously, and would decrease the complaints that fry were not delivered with enough regularity.

### 4.6.5 Improving Advertising

We observed that the farmers rely mainly on word of mouth and roadside signs as their sole means of advertisement. Therefore, they do not reach audiences outside of their local area. We recommend that INCOPESCA create a website containing locations, amenities, and traveling directions of trout farms throughout Costa Rica. This will draw in more tourism and increase the

potential economic gain of the farms, allowing the farmers to expand their businesses and therefore expand the trout farming industry. We also recommend that farmers that have internet access set up accounts on currently existing travel websites, such as www.tripadvisor.com.

### 4.6.6 Increasing Compliance with Legal Standards

Currently, there is no system within INCOPESCA monitoring whether farmers are complying with legal standards. A majority of farmers do not meet the legal standards and do not feel the need to do so. Informing farmers of the importance of these standards and providing them with the forms to meet them would help to combat the issue. If their legal status was verified periodically by INCOPESCA then farmers would have more of an incentive to comply. Once the farmers comply with these standards, they can then post that they meet these standards making their products more trustworthy to tourists and locals.

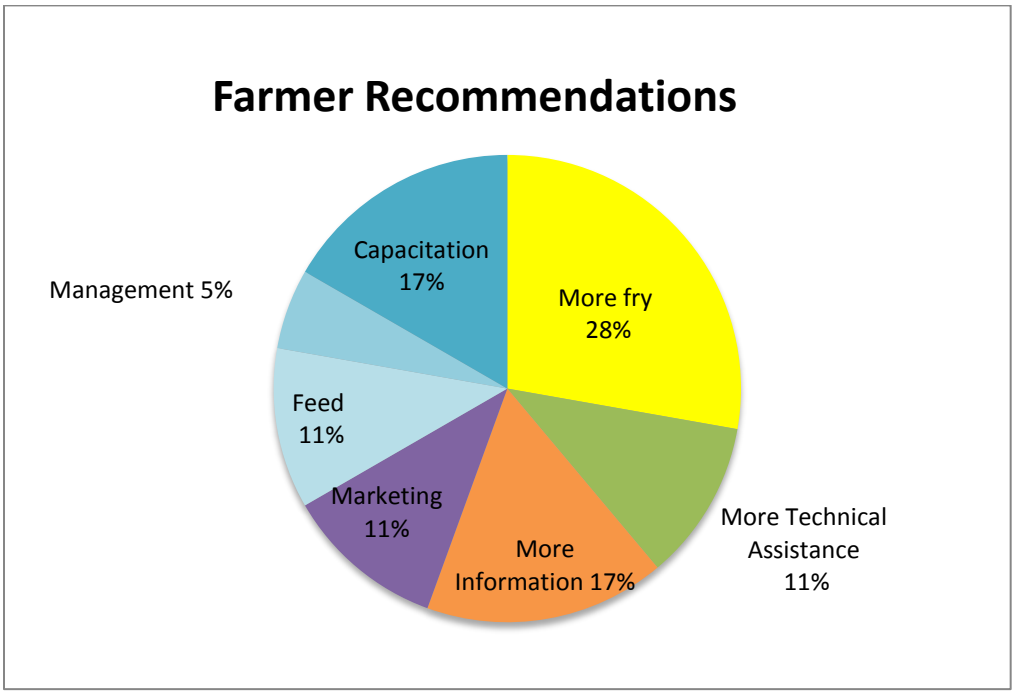


**Figure 11: Recommendations Requested by Farmers**

## Chapter 5: Conclusion

The purpose of our project was to improve production quality and marketing in order to expand the trout farming industry beyond the scope of current expectations through the creation of an all-inclusive reference of uniform trout farming practices. We identified the best practices for trout farming through research and communication with INCOPESCA and used our gathered knowledge to adapt these practices for Costa Rica.

All of the data collected from our interviews and observations during our study was complied in a database containing contact information, general farm characteristics, trout production, sales, and licensing. We then analyzed this information to identify areas within the trout farming industry that could be improved upon and should be considered when outlining best practices manual. We also provided recommendations to INCOPESCA to improve their effectiveness in facilitating the growth and longevity of the trout farming industry.

We envision that the products of our study will improve trout farming but Costa Rica as a whole. Our manual will provide farmers with a set of comprehensive practices specific to Costa Rican trout farming which they can implement at their farms. Providing our standards of practice are followed, environmental contamination will be reduced, the use of natural resources will be minimized, and the aquaculture industry in Costa Rica will continue to advance. These practices will provide basic assistance to trout farmers, alleviating the need for INCOPESCA's assistance which will allow for its resources to be invested in improving other areas within their agency.

Through our database of information and recommendations to INCOPESCA, we are confident that improvements will be made within the agency and in the way INCOPESCA aids trout farmers. By providing better technical assistance and more education on all aspects of trout farming, farms can improve their business practices, as well as their finished product. While the trout farming industry in Costa Rica is relatively small, compared with the tilapia and shrimp industries, it has enormous potential to expand and become more profitable. We strongly feel that this potential can be met given the resources our study has provided.

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**Appendix A: English Manual**

# Good Practices for the Cultivation of Trout in Costa Rica

Danielle Beland, Jonathan Buckley,
Laura Miggins, and Allyson Warren
Worcester Polytechnic Institute
and INCOPESCA

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# Introduction

We are four students from Worcester Polytechnic Institute completing our Interactive Qualifying Project. We come from a variety of educational backgrounds including Actuarial Mathematics, Biology, Biotechnology, and Mechanical Engineering. We have performed multiple interviews throughout Costa Rica, and worked closely with INCOPESCA to develop this manual.

INCOPESCA is a government agency dedicated to promoting, managing, and coordinating aquaculture activities in Costa Rica. They aim to achieve conservation, development, and sustainable use of aquaculture resources, as well as higher quality standards in the industry. With this manual INCOPESCA hopes to improve the standards of trout farming and provide a tool for farmers to become more self-sufficient.

This guide contains good trout farming practices specifically for Costa Rica. We define "good practices" as those that meet legal and heath standards for Costa Rica, while also being environmentally conscious and sustainable. Using the good practices provided in the manual will help increase the growth and survival rate of trout, leading to an increase in the production rate of the farm as a whole.

The purpose of this guide is to help trout farmers in Costa Rica effectively manage their farms. Following these recommendations will increase profits and quality of product, reduce disease, and decrease negative impacts on the environment.

We have provided forms within the Appendix of the manual for you to record daily and weekly information. These records are intended for your own use and are necessary in order to become certified by INCOPESCA.

Figuure 1: Rainbow Trout

## Site Selection

Test the pH and temperature of the proposed water source before starting a farm. The pH should be between 6.5 and 8.5. The location needs to be a place where the water temperature can naturally be between 12 and 18 °C. Usually this water temperature is found at high altitudes around 1500 meters.

Large ponds are less expensive to build, but small ponds are easy to maintain and less expensive to manage. The chosen place must have the access to basic services (drinkable water, phone, etc.). The land should be sloped to allow for water movement and effective drainage. Placing the farm downstream from a water source allows you to utilize gravity instead of pumps to transport water which will lower the costs of operation.

The site must have ample access to water during both the wet and dry seasons. Do not use a water source that is near an agricultural or industrial area. These areas add contaminants and pollutants to the water and may negatively affect your farm. Water can come from the following sources:

### Springs and Wells

- Temperature is constant
- Low dissolved oxygen content
- Water flow is constant

### Rivers

- Variable level of contamination
- Fluctuation in temperature and flow depending on season

### Ponds and Lakes

- Variable contamination level
- Variable temperature
- Variable dissolved oxygen content

## Stocking Density

If there are too many trout in a tank, they will compete for space, oxygen and feed. This will lead to injuries and an increase in stress.

The number of trout that should be in a tank depends on water temperature, biomass, tank design, water change frequency, and water flow.

The water flow must be calculated as the entire spare of the water in every pond per unit of time. The flow should be sufficient to maintain the water quality, but not so high that it can cause excessive activity for trout. See Figure 2 for the volume necessary for 10,000 trout at a certain temperature of water.

| Necessary Volume for 10000 Trout according to the Temperature of the Water | | | | | | |
|---|---|---|---|---|---|---|
| Length of the trout | Minimum volume in Liters/Minute for 10.000 Trout According to the Temperature of the Water | | | | | |
| | 5° | 7° | 10° | 12° | 15° | 17° |
| 6 | 25 | 30 | 35 | 40 | 45 | 55 |
| 8 | 60 | 70 | 80 | 90 | 100 | 125 |
| 10 | 105 | 120 | 140 | 165 | 195 | 235 |
| 12 | 170 | 190 | 215 | 265 | 315 | 380 |
| 14 | 265 | 300 | 335 | 415 | 485 | 575 |
| 16 | 390 | 425 | 465 | 580 | 700 | 840 |
| 18 | 565 | 620 | 680 | 800 | 930 | 1140 |
| 20 | 780 | 865 | 930 | 1150 | 1340 | 1600 |
| 22 | 1030 | 1150 | 1280 | 1450 | 1680 | 2000 |
| 24 | 1320 | 1440 | 1575 | 1740 | 1970 | 2300 |
| 26 | 1675 | 1765 | 1900 | 2075 | 2300 | 2625 |

Figure 2: Stocking Density chart

## To Determine the Proper Stocking Density:

Measure the water temperature. Find the column corresponding to that water temperature.
If you know the length of the fish in the tank and the number of fish in the tank and you want to determine the necessary water flow rate:
Find the flow rate corresponding to 10,000 fish for your temperature and fish length.
Divide your number of fish by 10,000
*(EX: For a tank with 1,000 fish: 1,000/10,000 = .1)*
Multiply the flow rate identified in step 1, by the number you obtained in step 2. This will give you the flow rate you need in Liters/minute
*(EX: For a 17 C tank, with 26 cm fish, the flow rate would be 2625 for 10,000 fish. For 1,000 fish, 2625 * .1 = 262.5 Liters/minute needed)*
To convert the flow rate to Liters/second, divide the flow rate in Liters/minute by 60
*(EX: For our tank with 1,000 26 cm fish at 17 C, 262.5/60 = 4.375 liters/second)*

To determine the flow rate of your water source:
Use a bucket whose volume you already know.
Place the bucket in the path of the water inflow so that it collects ALL of the incoming water.
Using a stopwatch, measure the amount of time needed to completely fill the bucket.
Divide the volume of the bucket in liters by the amount of time in seconds needed to fill the bucket.
*(EX: for a 40 liter bucket, that was filled in 16 seconds: 40/16 = 2.5 liters/second)*
To determine the flow rate in liters per minute, multiply the flow rate in liters/second by 60.
*(EX: for our previous bucket and time, 2.5 * 60 = 150 liters/minute)*

In order to have 10,000 trout at a certain length (blue) at a certain temperature (green), you need to identify the corresponding flow rate
*(EX: For a 15 C tank with 18 cm fish, you need 930 liters/minute.*
*For a 17 C tank with 24 cm fish, you need 2300 liters/minute.)*

If this water flow rate is unobtainable given your water source, divide your flow rate by the flow rate needed for 10,000 trout at your conditions
*(EX: For a 15 C tank with 22 cm fish, for 10,000 trout you need 1680 liters/minute. However you have previously determined the water flow rate on your farm is 200 liters/minute. 200/1680 = .119)*
Multiply this number by 10,000, to determine the maximum number of fish you should have in that tank.
*(EX: 10,000 * .119 = 1190 fish)*

# Sanitation Requirements

## How to Clean a Tank

A tank should be cleaned when there is more than 30mg of solids per liter of water. Suspended materials in the water can seriously effect the health of the trout. It can cause high stress levels, disease, reduced growth rates, and death. Routinely remove debris from the tank using a siphon hose or hand net.

Both concrete and earthen tanks should be drained, cleaned, and allow to dry between selling cycles using 200 grams of calcium carbonate **per square meter**. It is important then to let the tank be exposed to the sun for 36 hours and then fill it back up with water. Concrete tanks should also be cleaned using the following procedure.

- Do not feed the trout for one day
- Lower the level of the water in the tank
- Allow the trout to stir up debris on the bottom
- When the tank is clean, raise the water level again

For both concrete and earthen tanks, check the pH of the water prior to restocking.

## How to Maintain a Clean Worksite

- Sanitation should be practiced to prevent disease transmission through personnel, equipment, and water.
- Equipment and fish holding units should be sanitized using sodium hypochlorite and thoroughly dried between uses.
- All workers should wash their hands between handling of equipment, chemicals, and fish from different tanks to ensure that there is no cross contamination. Workers should also wear gloves to protect themselves. People, vehicles, and equipment coming from other farms should be disinfected in order to prevent contamination from other farms.

# How to Maintain Water Quality

## How to Adjust Temperature

**Ideal Temperature: between 12 and 18 °C**

If the temperature of the water is outside of this range, there will be a higher chance of disease in the trout because the change in temperature lowers their immune system and pathogens take advantage of this weakness. The low temperatures cause a reduced growth rate that increases the time that it takes for the trout to arrive at the proper weight for sale. The high temperatures hasten the metabolism of the fish, which increases the demand for food and oxygen.

If the temperature is too high, add one or more points of entrance to the water.

Measure once in the morning and once in the afternoon. Register this information in Annex A.

## How to Adjust pH

- Providing a stable pH is generally more important than providing an exact value, as long as extremes are avoided. The pH of the tank water must be within **6.5 and 8.5**. Any pH outside of this range will lead to slow growth rates, gill damage, and possibly death.
- pH strips should be used to measure pH. Measure once per week and register this information in **Annex A**
- There are commercial products available that both raise and lower the pH level of water. Contact an INCOPESCA technician for assistance with adjusting your pH.

## How to Improve Dissolved Oxygen Content

The trout require a dissolved oxygen content level of 5 mg of oxygen per liter of water to survive and be healthy. A dissolved oxygen level less than 3 mg per liter of water is deadly for the trout. If the dissolved oxygen content is low, it can cause problems with stress for the trout and sanitary problems in the tanks. It can also reduce the growth rate of the trout. The decomposition of food and vegetation can cause a decrease in the dissolved oxygen level.

Each tank should have a different source of fresh water. If the same water is being used for more than one tank, it is recommended that the same water should not be used for more than 4 tanks. When water is shared from tank to tank, the stocking density should be lower after each tank. (See figures 3 and 4)

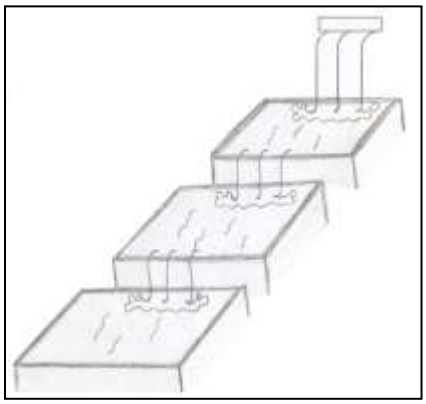


Figure3: Tanks in Series

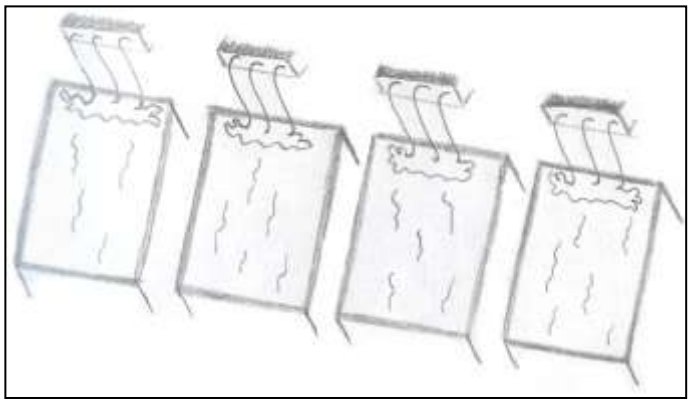


Figure 4: Tanks with independent water source

In the case of tanks in series, the dissolved oxygen content diminishes while the water moves further than the first tank

Indications that there is an incorrect level of dissolved oxygen:

- The fish swim to the area of the tank with the lowest temperature, even if is too cold
- The fish attempt to breathe the air outside the tank
- The fish gather in the entrance of water
- High number of deaths

Add one or more than the following methods of aeration to increase the dissolved oxygen content:

- Add one or more new points of entrance into the tank
- Build a stair step pathway in the path of the water(See figure 5) expand
- Add obstacles to impede the path of the water (See figure 6)
- Enlarge the height of which the water falls in the tank (See figure 7)

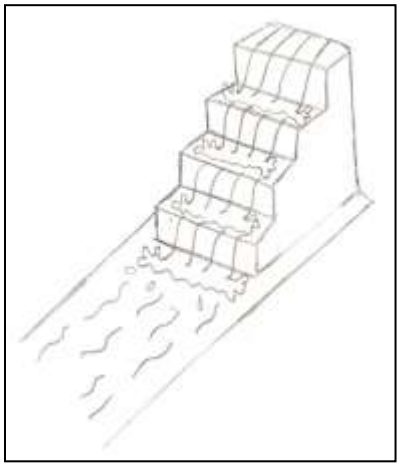


Figure 5: Stairstep

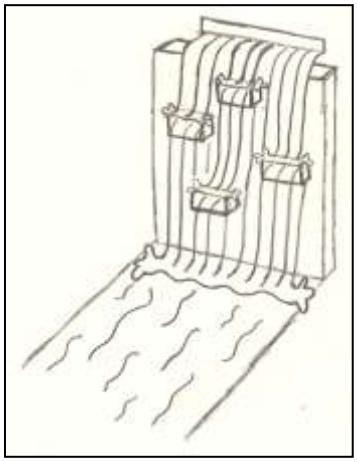


Figure 6: Obstacles

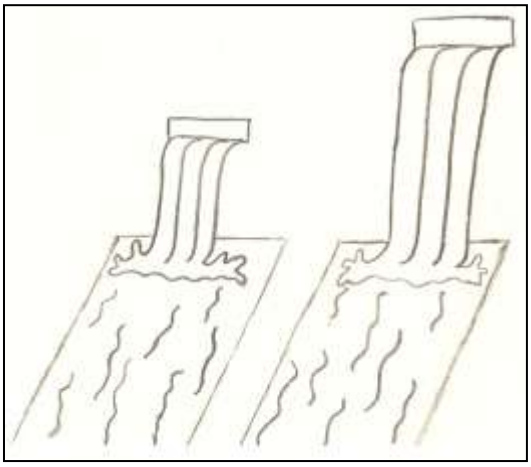


Figure 7: Height

## Recieving Fry

Fry should be acquired from seed production centers, where the quality of the fry are guaranteed and are compiled using professional methods.

When the fry arrive at farm, it is important to acclimate them to the temperature and pH of the water. For this, it is recommended to follow these steps to assure the highest rate of survival of the fry.

- Place the fry gently in the tank and wait for 25 minutes (See figure 8).
- Then open the bag and add small quantities of water until the temperature of the water in the bag is the same with the tank temperature
- Incline the bag and open it to let the fry out (See figure 9).

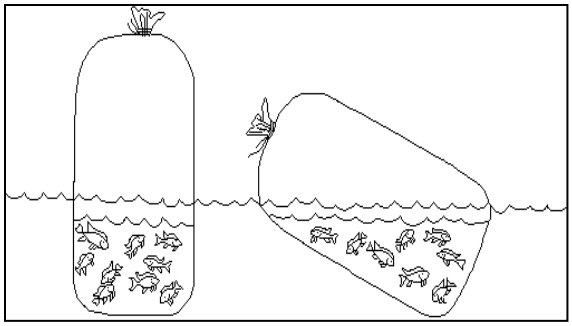


Figure 8: Bags of Fry

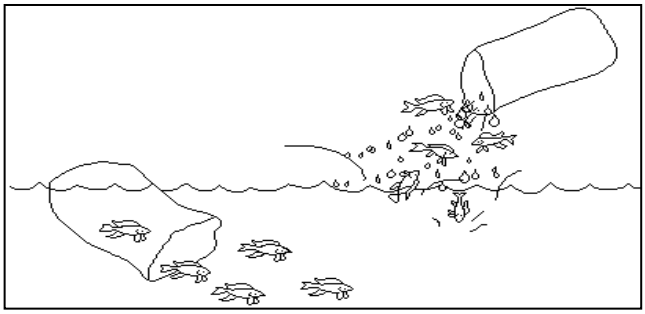


Figure 9: Left is Correct, Right is Incorrect

# Calculations

## Weight of trout

Determine the average weight of the fish in each tank once every month. Repeat the following method of calculating average weight for each tank.

- Weigh a bucket half full of water (B value)
- Using a dragging net, catch fish and add them to this bucket
- Make sure to record the number of fish in the bucket in Annex A.
- Weigh the bucket full of water and fish (A value)
- To determine the weight of just the fish, subtract the weight of the bucket full of water from the weight of the bucket full of water and fish (C value). Record all C values in Annex A.

**A – B = C**

A: Weight of bucket, water, and fish

B: Weight of just bucket and water

C: Weight of just Fish

- Repeat this process 3-4 times, until you have sampled about 10% of the tank population.
- To determine **average weight**, add all of the C values together and divide by the number of fish sampled. Record this information in **Annex B**
- To determine **trout per kg**, divide 1000 by the average weight. Record this information in **Annex B**
- To determine the **biomass** of each tank, multiply the average weight of trout by the total number of fish in the tank. Record this information in **Annex B**

## Calculating Average Length

To calculate the average length, measure each fish lengthwise that you weigh during the calculation of average weight. After each fish is measured, add all of the lengths together. Then divide by the total number of fish measured. Record this information in **Annex B**

## Calculating Monthly Growth Rate

Determine a monthly growth rate of each tank. Subtract the average weight from last month from the average weight this month. Divide by 30. Record this information in **Annex B**

$$\frac{\text{Last month's average weight - This month's average weight}}{30}$$

## How to Monitor Tanks

In order to monitor each tank, we recommend assigning each tank a number. Take measurements (area, volume) and record information for each individual tank on separate record sheet (see Annex D). When handling fish, make sure your hands are wet so that you do not remove the mucus layer of the fish.

- Measure pH & temperature twice daily, once in the morning and once at night. The pH should be measured once per week. Record this information in Annex D
- Record number of daily mortalities in each tank in Annex D
- Record amount of food given daily to each tank in Annex D
- Record Instances of disease in each tank in Annex D
- Record any other observations in Annex D

# Feed

Trout should be fed every day. Store bought food is easy to maintain, deteriorates slower than homemade food, and is given in a fixed quantity. Overfeeding will lead to poor water quality, which effects the trout's growth rate, stress level, and overall health. Since food accounts for 50-60% of the cost of running a farm, overfeeding also wastes money. Underfeeding will reduce the growth rate and full size potential of the trout.

## Feed quantity

Food quantity depends on biomass, water quality, and temperature. In order to determine the correct food quantity, the following procedure should be followed. The number of kilograms of trout in each tank should be determined using the method described under "Calculating Average Weight" section. After the number has been calculated, find the column corresponding to it on the table below. Then, find the row corresponding to the temperature of the tank. The intersection of the row and column will give you a feeding dosage as a percentage. Multiply this number by the number of kg of trout. Then divide that number by 100 to calculate the quantity of feed to use per day for that tank.

**(Kg of Trout x Feeding Dosage Percentage) ÷ 100 = Feed Quantity**

| Temperature (°C) | Number of Fish per kilo | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5592 | 5592 | 669 | 194 | 83.2 | 43.3 | 25.8 | 16.1 | 10.8 | 7.6 | 5.5 |
| | | 669 | 194 | 83.2 | 43.3 | 25.8 | 16.2 | 10.8 | 7.6 | 5.5 | |
| | Length of Fish (cm) | | | | | | | | | | |
| | 2.5 | 2.5 | 5 | 7.6 | 10 | 12.7 | 15.2 | 17.8 | 20.3 | 22.8 | 25.4 |
| | | 5 | 7.6 | 10 | 12.7 | 15.2 | 17.8 | 20.3 | 22.8 | 25.4 | |
| 8 | 4.3 | 3.6 | 3 | 2.3 | 1.7 | 1.4 | 1.2 | 1 | 0.9 | 0.8 | 0.7 |
| 9 | 4.5 | 3.8 | 3 | 2.4 | 1.8 | 1.5 | 1.3 | 1.1 | 1 | 0.9 | 0.8 |
| 10 | 5.2 | 4.3 | 3.4 | 2.7 | 2 | 1.7 | 1.4 | 1.2 | 1.1 | 1 | 0.9 |
| 11 | 5.4 | 4.5 | 3.6 | 2.8 | 2.1 | 1.7 | 1.5 | 1.3 | 1.1 | 1 | 0.9 |
| 12 | 5.8 | 4.9 | 3.9 | 3 | 2.3 | 1.9 | 1.6 | 1.4 | 1.3 | 1.1 | 1 |
| 13 | 6.1 | 5.1 | 4.2 | 3.2 | 2.4 | 2 | 1.6 | 1.4 | 1.3 | 1.1 | 1 |
| 14 | 6.7 | 5.5 | 4.5 | 3.5 | 2.6 | 2.1 | 1.8 | 1.5 | 1.4 | 1.2 | 1.1 |
| 15 | 7.3 | 6 | 5 | 3.7 | 2.8 | 2.3 | 1.9 | 1.7 | 1.5 | 1.3 | 1.2 |
| 16 | 7.8 | 6.5 | 5.3 | 4.1 | 3.1 | 2.5 | 2 | 1.8 | 1.6 | 1.4 | 1.3 |
| 17 | 8.4 | 7 | 5.7 | 4.5 | 3.4 | 2.7 | 2.1 | 1.9 | 1.7 | 1.5 | 1.4 |
| 18 | 8.7 | 7.2 | 5.9 | 4.7 | 3.5 | 2.8 | 2.2 | 1.9 | 1.7 | 1.6 | 1.5 |
| 19 | 9.3 | 7.8 | 6.3 | 5.1 | 3.8 | 3 | 2.3 | 2 | 1.8 | 1.7 | 1.6 |
| | Amount of Feed (%) | | | | | | | | | | |

Figure 10: Amount of Feed

### Example of Feed Quantity Calculation

**For a tank with 1000 trout with average weight of 93.46 g.**
**Biomass: 1000 * 93,46 = 93460 grams**
**Number of trout by kilo: 1000/93,46 = 10.7**
**For 8°C: ((93460/1000) * 0,9)/100 = 0.841 kilos of feed per day (841 grams)**
**For 19°C: ((93460/1000) * 1,8)/100 = 1.7 kilos of feed per day**

## Feed Frequency

The frequency of feeding depends on the size of the fish. Take a sample of about 10% of the population of each tank, and measure the length of each fish. Add all of the measured lengths together. Divide by the total number of fish measured to determine average fish length. Determine the feeding frequency by finding the row corresponding to the average length using the following table.

| Length of Fish cm) | Frequency of feeding per day |
|---|---|
| < 5 | 8-10 times |
| 5.1 - 10 | 4 times |
| 10.1 - 15 | 3 times |
| 15.1 - 22 | 2 times |
| > 22 | 1 time |

Figure 11: Feed Frequency per day

## Food Storage

Feed should be stored to maximize potency, and prevent degradation, infestation of pests, and mold growth. Keep food in an enclosed area that is well ventilated. The food container should be cleaned monthly. It is recommended to keep food in a covered and enclosed shed. Keep food away from,

- Moisture
- Dust
- Areas of waste disposal
- Chemicals
- Extreme temperature changes

## Other Things

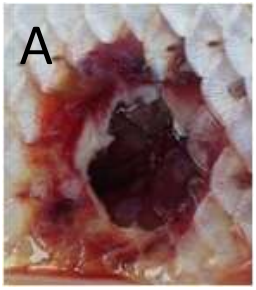
• Use the oldest feed first
• Put food on shelves, not on ground
• Leave a space of 30 cm between the feed and the walls of the shed
• The construction of the shed must have good air circulation

Figure 12: A Proper Shed

## How to Identify a Sick Trout

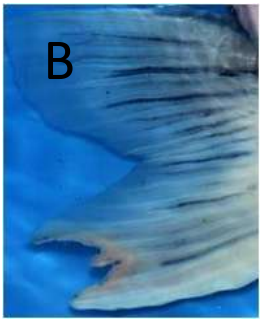
Disease is a common problem in trout farming. Some behavioral indications that the trout may be diseased are:

- Failure to feed
- Scratching or rubbing against objects
- Twitching or convulsions
- Crowding or gathering  in shallow water or at a water inflow
- Gasping at the water surface (also indicates low dissolved oxygen)
- Floating head, tail or belly up
- Abnormal breathing or gilling effort




When abnormal behavior is noticed, it is important to capture some of the suspected fish for closer examination. Upon examination, if any of the following symptoms are discovered, we recommend calling a veterinarian for proper treatment advice.

- Bloated or distended stomach full of fluid
- Open soars or lesions (see A)
- Lack of slime layer or rough feeling skin
- Frayed fins (see B)
- Pale gills (see E, right healthy left unhealthy)
- White cotton-like growths on body, head, or fins (see C)
- Blue-gray slime on gills or body surface
- Eroded or swollen gills
- White pinhead sized dots on head, body, and fins (see D)
- Any abnormal growths (see F)







## Use of Chemicals

When using any chemical, it is important to know the water conditions, health of the fish, and the chemical itself. Some commonly used chemicals are listed below. Before using any chemical on a tank, be sure to **consult a professional**.

### Copper Sulfate (CuSO4)

- Copper sulfate is used to adjust the water hardness. The water hardness can be determines using commercially available test kits. If the hardness is extremely low, or soft, this chemical can be very toxic to fish.

### Formalin

- Formalin is used to get rid of parasites. It also reduces the dissolved oxygen content. If it is stored at a temperature below 4°C then it converts to paraformaldehyde. This appears as a cloudy suspension, and is very toxic to fish and should not be used.

### Potassium Permanganate

- Potassium permanganate is used to raise the dissolved oxygen content of the water and control external parasites. When added to the tanks, it turns the water a pinkish purple.

### Oxytetracycline

- Oxytetracycline is used to treat bacterial infections in the tank. Fish cannot be sold for 21 days after treatment with this chemical.

## How to Protect Trout from Predators

Netting can be used to protect trout from predators, such as birds. The netting should be secured to prevent predators from entering the tanks. (see figure 13). Chained dogs also help keep potential predators away from tanks. Dogs should be kept far enough away from the tanks to prevent contamination.

Figure 13: Nets covering the tanks

## How to Classify Trout

Trout are carnivorous fish and they must be selected for homogeneous sizes to prevent cannibalism. This will prevent bigger trout from eating smallest trout. The selection can be made either by hand or by using a sorter (See figure 14), and it is necessary to realize the area of the pond with highest dissolved oxygen content. (Entry of the water in the tank)

Figure 14: A Sorter

## Marketing

When trout are commercialized, it is essential to maintain their quality. Making sure that the trout, as well as the area of sale is clean and maintained appropriately is essential to satisfying customers and guaranteeing their return. Register this Marketing information in Annex C.

### Use of Ice

The use of ice is very important to ensure and maintain the quality of trout. The ratio of fish to trout is 1:1, for every one kilo of fish it needs one kilogram of ice. The quantity of ice is not as important as the temperature of the ice (See figure 15).

| Temperature | Good Until |
|---|---|
| 0°C | 5-15 days |
| 5°C | 2-4 days |
| 15°C | 1 day |
| 25°C | 0 days |

Figure 15: Temperature Storage Table

## Advantages to the use of ice

1. Ice is a great coolant
2. It does not contaminate the trout
3. Ice is relatively cheap.
4. Ice cools trout rapidly
5. It can be transported easily and cool trout that are transported
6. The water melted from the ice washes the trout

## Phases of Deterioration in Trout

When a trout dies, it goes though 3 series of changes, which are:

- **Pre-Rigor**- The trout is flexible with firm texture and relaxed muscles (See figure 16)


Figure 16: Fish in Pre-Rigor

- **Rigor mortis**- The muscles contract and becomes rigid and the whole body becomes inflexible (See figure 17)


Figure 17: Fish in Rigor-Mortis

• **Post-rigor**- The muscles return to their relaxed state and in this phase, the trout starts to decompose quickly (See figure 18).


Figure 18: Fish in Post-Rigor

After the last phase of deterioration, the trout immediately goes into the phase of decomposition of the trout. If the trout is in any of the first three phases: (Pre-rigor, mortis Rigor or Post-rigor), the trout retains its freshness and therefore it can be consumed. But after the third phase, the trout cannot be eaten. The secret is to delay the time from one phase to the next phase. It is possible to do this by employing good preservation practices for trout and making use of the cold or ice.

## Evaluation of the Quality or Freshness of the Fish: Sensory analysis

There are several methods to evaluate the quality of the trout, but the most economic way is the sensory analysis, which is detailed here: (see figure 19):

| CARACTER | PESCADO FRESCO | *PESCADO DETERIORADO* |
|---|---|---|
| Piel | Color brillante<br>Mucus transparente | *Decolarada*<br>*Mucus opaco* |
| Ojos | Convexos<br>Transparentes<br>Brillantes | *Cóncavos*<br>*Lechosos*<br>*Opacos* |
| Branquias o Agallas | Rojas<br>Brillantes | *Amarillentas*<br>*Amarronadas* |
| Apariencia muscular | Firme, elástica<br>Color uniforme | *Blanda*<br>*Manchada* |
| Olor Muscular | Fresco olor a mar | *Fuerte mal olor* |
| *Órganos internos* | *Bien definidos*<br>*Olor suave* | *Autorizados*<br>*Olor ácido* |

Figure 19: Sensory Analysis

## Commercial Conditions

In commercial conditions, when storing fishing products, it is important to keep in mind:
1. It is true that the cold air helps to diminish the temperatures of the fish, but it is recommended to put ice with the trout, to prevent them from becoming dehydrated.
2. The products must not be placed on a wall or piled up very high, because air will not be able to be circulated properly around the trout
3. The products must not be in direct contact with the floor. It is recommended to store them on shelves or scaffolds of plastic or empty boxes.

4. Do not mix other seafood with the trout. If you go to the sell trout prepared with the entire fish and fillets, do not mix up the different boxes of entire fish and fillets.

5. Take in consideration the rotation of the product, that is to say first trout that gets to the market is the first to leave.

## Requisites of the Place of Selling

A) Make sure you have sufficient space to lodge one or two sellers, isothermal boxes for fish, tools (knives), material of packing, boards to cut.
B) Simple design of the place of sale without bends that make it difficult to clean and disinfect
C) It should have access to water with a wastepipe and a cleaning room to wash the fish.
D) Make sure there is sunlight or artificial light that allows the fish to be seen clearly
E) The surface of the counters should be a material that is easy to clean and disinfect (rustproof steel, thick plastic, high grade wall tiles, etc.).
F) Working area that has a drain to a wastepipe which can get rid of dirty water after cleaning the workspace.
G) The walls of the workspace should be made out of a washable and dirt-resistant material and of clear color.
H) The workspace should be protected against flies and other insects.
I) If there is enough space, it is recommended to have an exhibitor of fish, which is a type of table that has in the top part a slot preferably rustproof and sloping metal where the fish is placed between a thick layer of ice. This booth will have drainage to eliminate the ruined ice and liquid garbage.

**For more information, visit the link or contact INCOPESCA**
**http://www.incopesca.go.cr/Mercadeo/Mercadeo1.htm**

## Information on Licenses

The following licenses are necessary to trout farm in Costa Rica. Without them, farms can be closed at any time

### Authorization for Aquaculture Farms

- Article 82 of the fish law N º 8436, establishes that to develop an aquaculture farm, the person will have to obtain: "An authorization granted by the INCOPESCA for the culture of aquatic organisms in the marine waters or in continental waters".

### The Environmental Viability License

- The developer of the project must request the environmental viability license before the National Environmental Secretary (SETENA). According to the established decree Nº31849-MINAE-S-MOPT-MEIC. Named, Regulation on the evaluation of environmental impact

## The Concession of Use and Reuse of Water Fee

- Determines the amount of water each household, person, or project has the right to; based on the amount of water available. This license is very important for trout farmers, because it allows them to use the same amount of water in both the wet and dry seasons.

## The Veterinary Certificate of Operation License

- Allows for el Servicio Nacional de Salud Animal to regulate the conditions under which trout are produced. This one-time license available from SENASA ensures that the trout were raised in sanitary conditions, and that the trout are safe for consumption. This license is especially important for any trout farmer who is raising trout in a restaurant business or is looking to expand to larger markets.

## The Water Discharge Fee

- Encourages non-contaminating practices and encourages farmers to be conscious of the waste they put in the water. This one-time license is offered by Aguas MINAET.

# Contact Information

## Farmer Contact Information

| Nombre de Proyecto | Nombre de productor | Teléfono |
|---|---|---|
| **N/A** | Virginia Guillen Vargas | 2538-7127 |
| **La Trucha y El Gavlian** | Roberto Cerdas | 2538-8000 |
| **El Sapito** | N/A | 2534-1818 |
| **Rancho Ursca** | Juan Pablo Torres | 2577-1680 |
| **La Tranquera** | Pedro Nanco Nararro | N/A |
| **Montana de Truchas** | Ouido Chinchilla | 2577-1457 |
| **Truchas la Fuente** | Mariano Chinohilk | 2577-1752 |
| **Trucheros Las Rojas** | Alfredo Rojas Zamora | 2575-0061 |
| **Cipreces Preses** | Jorge Vives | 2551-1848 |
| **Trucha Rancho Grande** | Oliger Arce Gomez | 5000-33-3958 |
| **Truchos Chavolo** | Isaac Rivera Madriz | 1415-2577 |
| **Puerta de Osaca** | Ricardo Vensio Mora | 8373-2426 |
| **Rio Macho** | Oscar Gomez Calderon | N/A |
| **Guarco** | Luis Eladia Tencio Camacho | 8355-5071 |
| **Finca de Rio Macho** | Vidal Camacho Flores | 8868-2359 |
| **Madre Selva** | Alejandro Solano | 2200-0447 |
| **Finca Madre Selva** | Marcos Rojas | 8871-9889 |
| **Mirador de Quetzales** | Leanor Duando Guillen | 2200-5915 |
| **Creador de Truchas** | Oscar Gomez Calderon | 2541-3273 |
| **Truchicultura** | Fernando Guilizon de Churena | 511-30-81 |
| **Trucha Rica** | Cesar Vindes Otarola | 215-41-3323 |
| **El Lago de Pesca** | Mario Prado | 8398-9976 |
| **Lagos los Angeles** | Cepertero Angelo Cerrar | 2907-1307 |
| **Herer Trucha** | Felipe Rivera Chinchilla | 5091-4393 |
| **Pesca la Estrella** | Krispin Fuentes | 2571-1131 |
| **Trucha las Piedras** | Sergio Navarro Arias | 2571-1213 |
| **N/A** | Domimgo Gonzalgi Flores | 2541-3278 |
| **Suyiga** | Gerardo Chaca Suyiga | 2640-1023 |
| **Arco Iris de Los Santos** | Carlos Chacon Zuniga | 2740-1033 |
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| | | |
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| **Trucheria Hermanos Salas** | Ronad Salas | 2483-0736 |
| **Las Associacion Anónimo** | Carlos Chacon | 2640-1033 |
| **Centro Turistico San Lorenzo** | Roger Valverde Cerdas | 8366-2821 |
| **Pescada Trucha Carrucha** | Carlos Jimenez | 2445-1940 |
| **Valle Don Jesus** | Guillermo Duran | 2463-1711 |
| **Lagos Cimarron** | Enrique Quesada | 2771-1948 |
| **Trucha Nene** | Freddy Salazar | 2761-1933 |
| **N/A** | Victor Lopez | 2463-2365 |
| **Albergue de Montana** | Dagoberto Torres | 2533-2272 |
| **Truchas Recreativos el Manatiel** | Mario Valladares | 8331-3283 |
| **Montana Trucha de Carchi** | Geraldo Cortez | 2577-1457 |
| **Hotel Quelitales** | Jose Mejias | 2577-2222 |
| **Truchas Chabelo** | Isaac Rivera | 2577-1759 |
| **Rancho Urasca** | Juan Pablo Torres | 2577-1680 |
| **Tragon Lodge** | Issac Quiros | 2740-1051 |
| **Truchas Reales de Costa Rica** | Jose Miguel Viquez | 8376-4253 |
| **Truchero Roble Encino** | Rodolfo Elizondo | 2742-5006 |
| **Pescado Truchas la Paz** | Victor Ramiro | 8837-1238 |
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| **Truchero el Puente** | Enrique Torres | 2770-5532 |
| **Truchero las cocolisos** | Gonzalo Romero | 2742-5023 |

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| **Departamento de Acuicultura** | 2248-1196 |
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| **Centro truchicola Ojo de Agua de Dota** | 2200-5049 |
| **Estación acuícola los Diamantes** | 2763-3293 |
| **Oficina acuícola Ciudad Quesada** | 2460-6110 |
| **Estación acuícola Enrique Jiménez** | 2200-0293 |

## Annex A: To Weigh trout

| | Muestra 1 | Muestra 2 | Muestra 3 | Muestra 4 | Muestra 5 |
|---|---|---|---|---|---|
| Numero de trucha en el balde | | | | | |
| Peso de trucha total (Valor C) | | | | | |
| Peso Promedio | | | | | |

## Annex B: Monthly Registry

| | Enero | Febrero | Marzo | Abril | Mayo | Junio | Julio | Agosto | Septiembre | Octubre | Noviembre | Diciembre |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peso Promedio | | | | | | | | | | | | |
| Trucha por Kilo | | | | | | | | | | | | |
| Biomasa | | | | | | | | | | | | |
| Longitud Media | | | | | | | | | | | | |
| Tasa de Crecimiento Mensual | | | | | | | | | | | | |

## Annex C: Marketing Registry

| | Domingo | Lunes | Martes | Miércoles | Jueves | Viernes | Sábado |
|---|---|---|---|---|---|---|---|
| Número de kilos | | | | | | | |
| Número de trucha | | | | | | | |
| Precio | | | | | | | |
| Destino | | | | | | | |

## Annex D: Daily Registry

| Fecha | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Estanque #: | Domingo | | Lunes | | Martes | | Miércoles | | Jueves | | Viernes | | Sábado | |
| ¿Limpiado? | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No |
| | | | | | | | | | | | | | | |
| Mortalidades (Número) | | | | | | | | | | | | | | |
| Cantidad de alimento (kg) | | | | | | | | | | | | | | |
| ¿Observa enfermedades? | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No |
| | | | | | | | | | | | | | | |
| En caso afirmativo, ¿llama a un profesional? | | | | | | | | | | | | | | |
| pH | X | | X | | X | | | | X | | X | | X | |
| Temperatura | Mañana | Tarde | Mañana | Tarde | Mañana | Tarde | Mañana | Tarde | Mañana | Tarde | Mañana | Tarde | Mañana | Tarde |
| | | | | | | | | | | | | | | |
| Observaciones | | | | | | | | | | | | | | |

## Annex E: Licensing Forms

**Authorization for Aquaculture Farms**

**The Environmental Viability License**

**The Concession of Use and Reuse of Water Fee**

**The Veterinary Certificate of Operation License**

**The Water Discharge Fee**

## Annex F: Glossary

**Esterilizados:** Limpiar todos los instrumentos, equipo y superficies con el agua y líquido limpiador
**Patógenos:** Unos organismos que causa la enfermedad como bacterias, virus y hongos
**Metabolismo:** Procesamiento de una sustancia (comida, etc.) dentro de un organismo
**pH:** Una medida de la acidez de una solución como el agua, iguale a 7 para soluciones neutras
**Branquial:** Lo que la trucha usa para respirar
**Red de arrastre:** Una red que se usa para obtener las peces en el fondo del estanque
**Alevines:** Truchas jóvenes, menos que 3 cm
**Atarraya:** Una red circular con pequeños pesos distribuidos alrededor de su borde
**Biomasa:** La masa total de organismos vivos en un área particular o volumen
**Aleta cardal:** Las aletas en el extremo de la pez, opuesta de la cabeza
**Monitorear:** Probar en una base regular
**Depredadores:** Un animal que come a otros animales

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**Appendix B: Spanish Manual**

# Good Practices for the Cultivation of Trout in Costa Rica

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Worcester Polytechnic Institute
and INCOPESCA

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# Introducción

Somos cuatro estudiantes del instituto politécnico de Worcester que estamos completando nuestro proyecto de calificación interactivo. Venimos de una variedad de formaciones académicas incluyendo matemáticas actuariales, biología, biotecnología, y la ingeniería mecánica. Hemos realizado entrevistas múltiples en Costa Rica, y hemos trabajado con INCOPESCA para desarrollar este manual.

INCOPESCA es una agencia gubernamental dedicada a promover, gestionar y coordinar las actividades de la pesca y de la acuicultura en Costa Rica. Uno de sus objetivos es lograr la conservación, el desarrollo, y el uso sostenible de recursos de acuicultura, así como estándares más altos de calidad en la industria. Con este manual, INCOPESCA espera mejorar las condiciones del cultivo de la trucha y proporcionar una herramienta para que los granjeros lleguen a ser más autosuficientes.

Esta guía contiene buenas prácticas acuícolas para el cultivo de trucha, específicamente para Costa Rica. Definimos las "buenas prácticas" como los que cumplan los estándares legales, sanitarios, y técnicos, considerando la sostenibilidad de a actividad. Utilizar las buenas prácticas proporcionadas en el manual ayudará a mejorar al manejo de cultivo, llevando a un aumento en la tasa de la producción y mejorando la rentabilidad de los proyectos.

El propósito de este manual es ayudar a granjeros de la trucha en Costa Rica con eficacia a manejar sus granjas.  Siguiente que estas recomendaciones aumentarán ganancias y calidad de producto, reducirán enfermedades, y disminuirán impactos negativos en el ambiente.

Hemos proporcionado formularios dentro del Anexo del manual para registrar información diaria y semanal. Estos registros están destinados para su propio uso y que sean necesarias con el fin de ser certificado por INCOPESCA.

Figura 1: Trucha Arco Iris

## Seleccionar el Sitio

Pruebe el pH y la temperatura de la fuente del agua antes de comenzar una granja. Asegúrese de que el pH este entre 6.5 y 8.5. La fuente de agua debe tener una temperatura entre 12 y 18 °C. Generalmente esta temperatura de agua se encuentra a altitudes mayores de 1500 metros sobre el nivel del mar.

Los estanques grandes son menos caros de construir, pero los estanques pequeños son más fáciles para mantener y menos caro para administrar. El lugar seleccionado debe tener el acceso a servicios básicos (agua potable, teléfono, etc.). La topografía del terreno debe tener un cierto desnivel para permitir el movimiento de agua por gravedad. La ubicación de la granja con relación a la fuente de agua debe permitir utilizar la gravedad, en vez de bombas para transportar el agua, que suben los costos de operación.

El sitio debe tener un caudal mínimo de agua durante la época seca. No se debe usar una fuente de agua que está cerca de una zona agrícola o industrial. Estas zonas agregan los contaminantes al agua y pueden afectar negativamente a su granja. El agua puede venir de varias fuentes con características como las siguientes:

### Manantiales y pozos

- La temperatura es constante
- El contenido de oxígeno disuelto es bajo
- El flujo de agua es constante

### Ríos

- Un nivel de contaminación variable
- La fluctuación en temperatura y flujo depende del estación

### Lagunas y lagos

- Nivel de contaminación variable
- Temperatura variable
- Contenido de oxígeno disuelto variable

## Media de Densidad

Si hay demasiadas truchas en un estanque, habrá una fuerte competencia por el espacio, el oxigeno y el alimento. Este conducirá a peleas que causaran heridas y un aumento del estrés en la población.

El número de truchas que debería estar en un estanque depende de temperatura de agua, biomasa, el diseño de estanque y del flujo del agua.

El flujo de agua deber ser calculado como el recambio total del agua en cada estanque por unidad de tiempo. El flujo debería ser suficiente para mantener la calidad de agua, pero no tan alto que puede causar una actividad excesiva de las truchas. Ver la figura 2 para el caudal necesario para 10,000 truchas según la temperatura del agua.

| Caudal Necesario para 10,000 Truchas Según la Temperatura del Agua | | | | | | |
|---|---|---|---|---|---|---|
| Longitud de las Truchas (cm) | Caudal Mínimo Necesario en Litros/Minuto para 10,000 Truchas Según la Temperatura del Agua | | | | | |
| | 5 | 7 | 10 | 12 | 15 | 17 |
| 6 | 25 | 30 | 35 | 40 | 45 | 55 |
| 8 | 60 | 70 | 80 | 90 | 100 | 125 |
| 10 | 105 | 120 | 140 | 165 | 195 | 235 |
| 12 | 170 | 190 | 215 | 265 | 315 | 380 |
| 14 | 265 | 300 | 335 | 415 | 485 | 575 |
| 16 | 390 | 425 | 465 | 580 | 700 | 840 |
| 18 | 565 | 620 | 680 | 800 | 930 | 1140 |
| 20 | 780 | 865 | 930 | 1150 | 1340 | 1600 |
| 22 | 1030 | 1150 | 1280 | 1450 | 1680 | 2000 |
| 24 | 1320 | 1440 | 1575 | 1740 | 1970 | 2300 |
| 26 | 1675 | 1765 | 1900 | 2075 | 2300 | 2625 |

Figura 2: Tabla de Densidad de Siembra

## Para Determinar la Media de Densidad

Mida la temperatura del agua. Busque la columna correspondiente a la temperatura del agua.

Si conoce la longitud de los peces en el tanque, y el número de peces en el tanque y desea determinar el caudal de agua necesario:
1.) Encuentre el caudal correspondiente a 10.000 peces por su temperatura y la longitud de sus peces.
2.) Divida su número de peces por 10.000
*(Ejemplo: Para un estanque con 1.000 peces: 1.000 / 10.000 = 0,1)*
3.) Multiplique el caudal identificado en el paso 1, por el número que obtuvo en el paso 2. Esto le dará el caudal que necesita en litros / minuto
*(Ejemplo: Para un estanque de 17 C, con peces de 26 cm, el caudal necesario para 10.000 peces será 2625. Para 1.000 peces, 2625 * .1 = 262,5 litros / minuto es necesario)*
4.) Para convertir el caudal a litros / segundo, dividir el caudal en litros / minuto por 60
*(Ejemplo: Para un estanque con 1.000 peces de 26 cm en 17 C, 262.5/60 = 4,375 litros / segundo)*

## Para Determinar el Caudal de la Fuente de Agua:

Utilice un balde cuyo volumen ya sabe.
1.) Coloque el balde en el camino de la entrada de agua de modo que recoja toda el agua entrante.
2.) Usando un cronómetro, mida la cantidad de tiempo necesario para llenar completamente el balde.
3.) Divida el volumen del balde en litros por la cantidad de tiempo en segundos necesaria para llenar el balde.
*(Ejemplo: Para un balde de 40 litros, que se llenó en 16 segundos: 40/16 = 2,5 litros / segundo)*
4.) Para determinar el caudal en litros por minuto, multiplicar el caudal en litros / segundo por 60.
*(Ejemplo: Para el balde y el tiempo anterior, 2,5 * 60 = 150 litros / minuto)*

Para tener 10.000 truchas de una cierta longitud (azul en la tabla) a una cierta temperatura (verde en la tabla), es necesario identificar el caudal correspondiente
*(Ejemplo: Para un estanque de 15 C con peces de 18 cm, se necesita 930 litros / minuto.*
*Ejemplo: Para un estanque de 17 C con peces de 24 cm, se necesita 2300 litros / minuto).*
1.) Si esta tasa de flujo de agua es inalcanzable dada su fuente de agua, divida el flujo de agua por el

caudal necesario para 10.000 truchas en sus condiciones
*(Ejemplo: Para un estanque de 15 C con peces de 22 cm, 10.000 trucha necesitan 1680 litros / minuto. Sin embargo, ya ha determinado que la velocidad de flujo de agua en la granja es de 200 litros / minuto. 200/1680 = .119)*
2.) Multiplique este número por 10.000, para determinar el número máximo de peces que debe tener en ese estanque.
*(EX: 10.000 * .119 = 1190 peces)*

# Criterios de Saneamiento

## Para limpiar un estanque

Un estanque debe ser limpiado cuando se note muchos materiales suspendidos en la columna de agua. Los materiales suspendidos en el agua pueden afectar la salud de la trucha. Esto puede causar enfermedades, tasas de crecimiento reducidas, niveles altos de estrés, y la muerte. Rutinariamente se debe sacar los desechos de los estanques usando una manguera de sifón con una malla o cedazo, en la boca de la manguera que succionar para evitar el escape de las truchas.

Tanto los estanques de concreto como los de tierra deben ser drenados, limpiados, y secados entre los ciclos de cosecha. Se debe realizar una desinfección del estanque usando carbonato de calcio, (200 gramos por metro cuadrado), se debe dejar el estanque por 36 horas al sol y luego llenarlo. Los estanques de concreto deben ser limpiados usando el procedimiento siguiente:

- No alimentar a la trucha un día antes de realizar la limpieza
- Bajar el nivel del agua en el estanque
- Realizar la limpieza, aprovechando el movimiento de natación de la trucha, para remover los deshechos del fondo
- Cuando el estanque está limpio, levantar el nivel de agua otra vez
- No alimentar a la trucha después de la limpieza, hasta el otro día.

## Cómo Mantener un Lugar de Trabajo Limpio

Las condiciones sanitarias deben ser practicadas para prevenir la transmisión de enfermedades por el personal, equipo, y el agua.

El equipo y los baldes deben ser esterilizados usando el hipoclorito sodio (cloro).

Todos los trabajadores se deben lavar sus manos antes del manejo de equipo, productos químicos, y peces, para asegurar que no haya ninguna contaminación. Los trabajadores también deben llevar guantes para protegerse. Las personas, vehículos, y equipos procedentes de otras granjas deben ser desinfectados para prevenir la contaminación en la granja.

# Como Mantener la Calidad de agua

## Cómo Ajustar la Temperatura

**Temperatura ideal: entre 12 y 18˚C.**

Si la temperatura del agua está fuera de este rango, puede aumentar la probabilidad de enfermedad porque baja el sistema inmune de la trucha y los patógenos aprovechan para atacar. Las temperaturas bajas causan una tasa de crecimiento reducida, que aumenta el tiempo que tomará la trucha para llegar al peso de venta. Las temperaturas altas aumentan el metabolismo del pez, lo cual aumenta la cantidad de alimento, y oxigeno.

Si la temperatura es demasiado alta, agregue uno o varios puntos adicionales de entrada de agua.

Mida la temperatura una vez por la mañana y una vez por la tarde. Registre esta información en **Anexo A**.

## Cómo Ajustar el pH

El pH del agua del estanque debe estar **entre 6.5 y 8.5**. Cualquier pH fuera de este rango retardará las tasas de crecimiento, causará daño en las branquias, y posiblemente causará la muerte.

Las tiras del pH se pueden utilizar para medir este parámetro. Esta medida se puede realizar una vez por semana. Registre esta información en **Anexo A**.

Hay algunos productos comerciales disponibles que pueden subir y bajar el nivel del pH de agua. Contacte a un técnico de INCOPESCA para ayudar con el ajuste del pH.

## Como Mejorar el Contenido de Oxígeno Disuelto

Las truchas requieren una concentración de **5 mg de oxígeno por litro** del agua para que sobrevivir y mantenerse sanas. Las concentraciones de oxígeno disueltas menores de 3 mg por litro del agua son letales para la trucha. El contenido de oxígeno disuelto bajo, puede conducir a problemas de estrés y problemas sanitarios. El contenido de oxígeno disuelto bajo también puede reducir la tasa de crecimiento de la trucha. La descomposición de alimento y vegetación en el fondo de los estanques puede bajar el contenido de oxígeno disuelto.

Cuando las condiciones lo permitan, cada estanque debe tener un flujo de agua fresca directamente. Si la misma agua está siendo usada para más de un estanque, es recomendado hacerlo para un máximo de 4 estanques. En casos de reutilización del agua, la densidad de los peces debe ser disminuida en cada estanque, conforme aumente el número de veces que se usa. (Ver las figuras 3 y 4)

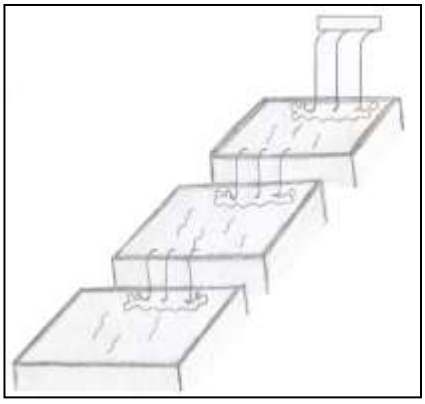


Figura 3: Estanques en Serie

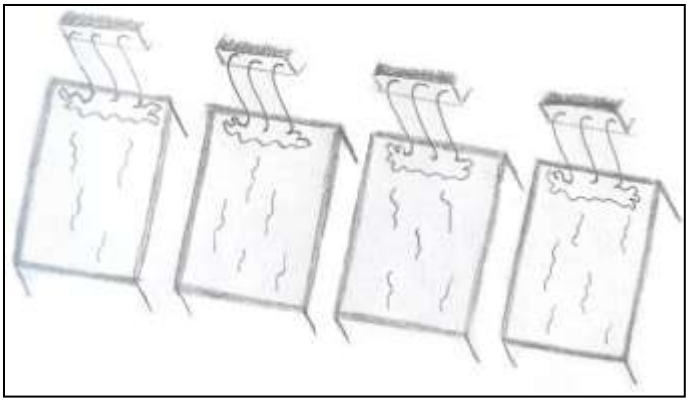


Figura 4: Estanques con Agua Independiente

En el caso de estanques en serie, el contenido en oxígeno disuelto disminuye mientras el agua se mueve más lejos del primer estanque.

Indicadores de contenido de oxígeno disuelto incorrecto:

- Los peces nadan a la zona con la temperatura más baja, incluso si es demasiado frío
- El pez saca la cabeza del agua y boquea buscando aire
- Los peces se reúnen en la entrada de agua
- Nivel de mortalidad alta

Agregar uno o más de los métodos siguientes de aeración para aumentar el contenido del oxígeno disuelto:

- Agregar uno o varios puntos nuevos de entrada de agua
- Construir una escalera en la vía de entrada de agua (Ver la figura 5)
- Agregar un plano inclinado en la vía de agua con obstáculos (Ver la figura 6)
- Aumentar la altura de la cual el agua cae en el estanque (Ver la figura 7)

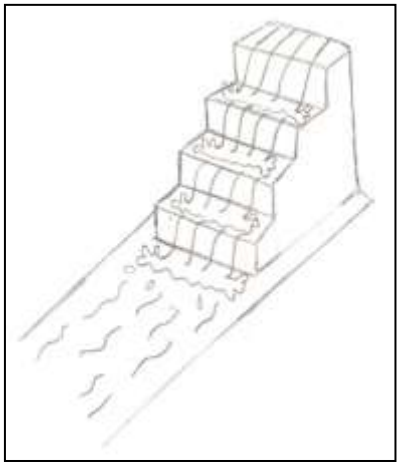


Figura 5: Escalera

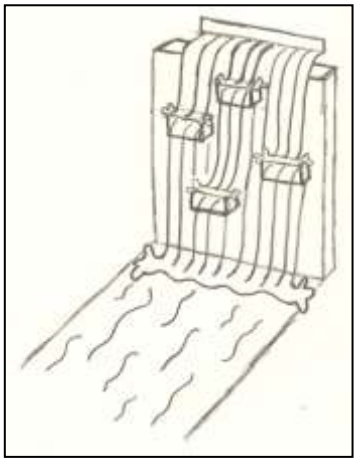


Figura 6: Obstáculos

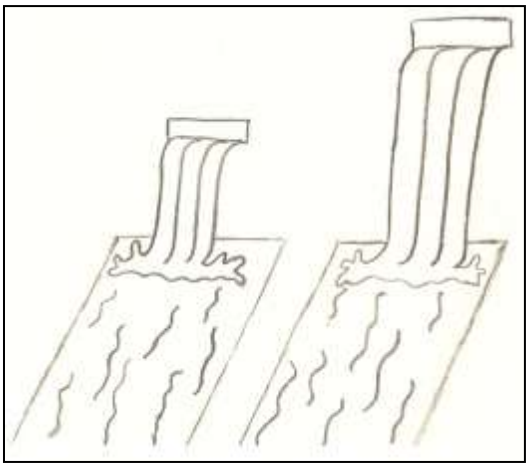


Figura 7: Altura

## Adquisición de Alevines

Los alevines se deben debe adquirir de centros de producción de semilla, donde se certifique la calidad de los mismos y se cumplan con aspectos técnicos de manejo básicos para asegurar el éxito de los proyectos.

Cuándo los alevines llegan al lugar donde van a ser sembrados, es importante aclimatarlos a condiciones de temperatura y pH del agua. Para esto se recomienda seguir los siguientes pasos para asegurar la tasa más alta de supervivencia de los alevines.

- Coloque suavemente la bolsa de alevines en el estanque y espere por 25 minutos (Ver la figura 8).
- Luego abra la bolsa y agregue gradualmente pequeñas cantidades de agua hasta que se equilibre la temperatura del agua de la bolsa con la del estanque
- Incline la bolsa y comience a liberar los alevines suavemente (Ver la figura 9).

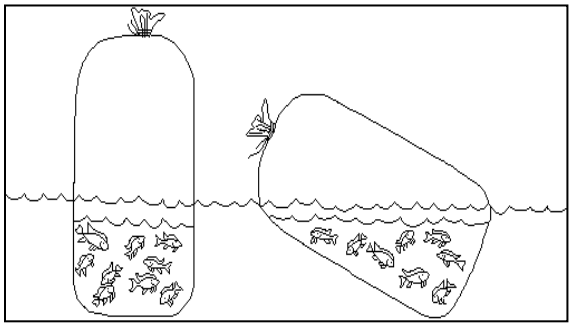


Figura 8: Bolsas de Alevines

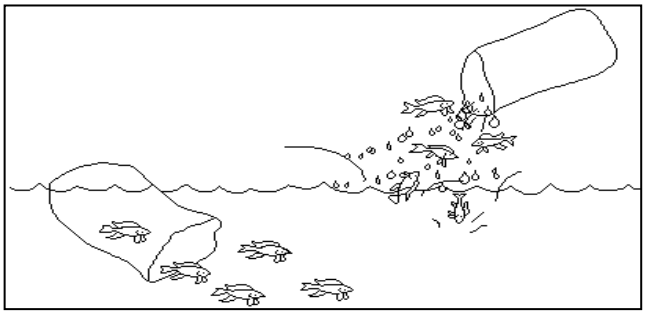


Figura 9: Izquierda Correcto, Derecha Incorrecto

## Cálculos

Cuando estamos manipulando las truchas, las manos deben estar húmedas para evitar el maltrato a los peces, y evitar la aparición de enfermedades.

### Peso de la trucha

Determine el peso promedio de las truchas en cada estanque una vez por mes. Repita el siguiente método de cálculo para sacar del peso promedio para cada estanque.

- Pese un balde con un tercio de agua (valor B)
- Utilizando una red de arrastre o atarraya capture los peces y colóquelos en el balde.
- Registre el número de truchas en el balde en **Anexo A**.
- Pese el balde lleno de agua y trucha (valor A)
- Para determinar el peso promedio de los peces (C), reste el peso del balde con agua (B) del peso del balde con agua y peces (A) Registre todos los valores de C en **Anexo A**.

**A – B = C**

A: Peso del balde, agua y peces.

B: Peso del balde con agua.

C: Peso de peces.

- Repita este proceso hasta que usted haya muestreado el 10 % de la población del estanque.

- Para determinar el **peso promedio**, sume todos los valores de C juntos y divida por el número total de peces muestreados. Registre esta información en **Anexo B**.
- Para determinar el número de **truchas por kilo**, divida 1000 por el peso promedio. Registre esta información en **Anexo B**.
- Para determinar la **biomasa** de cada estanque, Multiplique el peso promedio de la trucha en gramos por el número total de peces en el estanque (se deben llevar registros de sobrevivencia). Registre esta información en **Anexo B**.

### Cálculo de la Longitud Media

Para calcular la longitud media, mida cada trucha longitudinalmente (extremo de la cabeza al extremo de la aleta caudal. Ver la figura X), durante el cálculo del peso medio. Después de que cada trucha es medida, se suman todas las longitudes y esta cantidad se divide por el número total de las truchas medidas. Registre esta información en **Anexo B**.

### Cálculo de Tasa de Crecimiento Mensual

Determine la tasa de crecimiento mensual de cada estanque. Para esto reste el peso medio del mes pasado del peso medio del mes actual. Divídase por 30. Registre esta información en **Anexo B.**

$$\frac{\text{Peso promedio del mes pasado - Peso promedio de este mes}}{30}$$

## Como Monitorear los Estanques

Para una buena administración del proyecto en general, cada estanque debe de estar numerado. Tome medidas (área, volumen, etc.) y registre la información para cada estanque en la hoja de registro separada (ver **Anexo D**).

Mida la temperatura dos veces al día, una vez que en la mañana y una vez de noche. El pH se puede medir una vez por semana. Registre esta información en **Anexo D**.

Anote la mortalidad diaria en cada estanque en **Anexo D**.

Anote el cantidad de alimento suministrado diariamente a cada es tanque en **Anexo D**.

Anote los casos de enfermedad en cada tanque en **Anexo D**.

Registre cualquier otra observación en **Anexo D**.

## Alimentación

Las truchas se deben alimentar todos los días. La sobrealimentación produce una mala calidad del agua, lo que afecta el crecimiento de la trucha, el nivel de estrés, y en general su salud. Dado que los alimentos representan el 50-60% de los costos de producción de una granja, la sobrealimentación es perdida de dinero. La subalimentación reducirá la tasa potencial de crecimiento y el tamaño potencial de la trucha.

## Cantidad de Alimento

La cantidad de alimento depende de la biomasa, la calidad del agua, y la temperatura. Para determinar la cantidad correcta de alimento, el procedimiento siguiente debe ser seguido. El número de kilos de trucha en cada estanque debe ser determinado usando el método descrito en la sección sobre "Calcular el peso promedio". También es necesario conocer el número de peces por kilo. Conociendo el número de peces por kilo y la temperatura del agua, utilizamos la tabla que se muestra abajo (ver la figura 10). Se ubica la temperatura del estanque y en la intersección de esta fila y de la columna que tenemos localizada por el número de peces por kilo, se mostrara el porcentaje de alimentación con base en la biomasa total. Multiplique este número por la biomasa de la trucha y divida por 1000. Entonces divida ese número por 100 para calcular la cantidad de alimentación para utilizar por día para ese tanque.

**((Biomasa/1000) x Dosis de alimentación) ÷ 100 = Cantidad de alimento**

| Temperatura (°C) | Número de peces por kilo | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5592 | 5592 | 669 | 194 | 83.2 | 43.3 | 25.8 | 16.1 | 10.8 | 7.6 | 5.5 |
| | | 669 | 194 | 83.2 | 43.3 | 25.8 | 16.2 | 10.8 | 7.6 | 5.5 | |
| | Longitud de los peces (cm) | | | | | | | | | | |
| | 2.5 | 2.5 | 5 | 7.6 | 10 | 12.7 | 15.2 | 17.8 | 20.3 | 22.8 | 25.4 |
| | | 5 | 7.6 | 10 | 12.7 | 15.2 | 17.8 | 20.3 | 22.8 | 25.4 | |
| 8 | 4.3 | 3.6 | 3 | 2.3 | 1.7 | 1.4 | 1.2 | 1 | 0.9 | 0.8 | 0.7 |
| 9 | 4.5 | 3.8 | 3 | 2.4 | 1.8 | 1.5 | 1.3 | 1.1 | 1 | 0.9 | 0.8 |
| 10 | 5.2 | 4.3 | 3.4 | 2.7 | 2 | 1.7 | 1.4 | 1.2 | 1.1 | 1 | 0.9 |
| 11 | 5.4 | 4.5 | 3.6 | 2.8 | 2.1 | 1.7 | 1.5 | 1.3 | 1.1 | 1 | 0.9 |
| 12 | 5.8 | 4.9 | 3.9 | 3 | 2.3 | 1.9 | 1.6 | 1.4 | 1.3 | 1.1 | 1 |
| 13 | 6.1 | 5.1 | 4.2 | 3.2 | 2.4 | 2 | 1.6 | 1.4 | 1.3 | 1.1 | 1 |
| 14 | 6.7 | 5.5 | 4.5 | 3.5 | 2.6 | 2.1 | 1.8 | 1.5 | 1.4 | 1.2 | 1.1 |
| 15 | 7.3 | 6 | 5 | 3.7 | 2.8 | 2.3 | 1.9 | 1.7 | 1.5 | 1.3 | 1.2 |
| 16 | 7.8 | 6.5 | 5.3 | 4.1 | 3.1 | 2.5 | 2 | 1.8 | 1.6 | 1.4 | 1.3 |
| 17 | 8.4 | 7 | 5.7 | 4.5 | 3.4 | 2.7 | 2.1 | 1.9 | 1.7 | 1.5 | 1.4 |
| 18 | 8.7 | 7.2 | 5.9 | 4.7 | 3.5 | 2.8 | 2.2 | 1.9 | 1.7 | 1.6 | 1.5 |
| 19 | 9.3 | 7.8 | 6.3 | 5.1 | 3.8 | 3 | 2.3 | 2 | 1.8 | 1.7 | 1.6 |
| | Dosis de alimentación (%) | | | | | | | | | | |

Figura 10: Dosis de alimentación

## Ejemplo de cálculo de cantidad de alimentación

Para un estanque con 1000 truchas con peso promedio de 93.46 g.
Biomasa: 1000 * 93.46 = 93460 gramos
Numero de truchas por kilo: 1000 / 93.46 = 10.7
Para 8˚C: ((93460/1000) * 0.9) / 100 = 0.841 kilos de alimento por día (841 gramos)
Para 19˚C: ((93460/1000) * 1.8) / 100 = 1.7 kilos de alimento por día

## Frecuencia de alimentación

La frecuencia de la alimentación depende del tamaño de los peces. Tome una muestra de aproximadamente 10% de la población de cada estanque, y mida la longitud de cada pez. Agregue todas

las longitudes medidas juntos. Divida por el número total de peces medidos para determinar la longitud media de los peces. Para determinar la frecuencia de la alimentación, encontrar la fila correspondiente a la longitud media usando la tabla siguiente (ver la figura 11).

| Longitud de peces (cm) | Frecuencia de alimentación por día |
|---|---|
| < 5 | 8-10 veces |
| 5.1 - 10 | 4 veces |
| 10.1 - 15 | 3 veces |
| 15.1 - 22 | 2 veces |
| > 22 | 1 vez |

Figura 11: Frecuencia de alimentación por día

## Almacenamiento del alimento

El alimento se debe almacenar correctamente para prevenir se degradación, la infestación de parásitos, y el crecimiento de hongos y mohos. Mantenga el alimento en un lugar cerrado que esté bien ventilado. Se recomienda mantener los alimentos en una bodega especialmente construida para este fin (Ver la figura 12). Mantenga el alimento lejos de:

- Humedad
- Polvo
- Áreas de eliminación de residuos
- Químicos
- Cambios extremos de temperatura

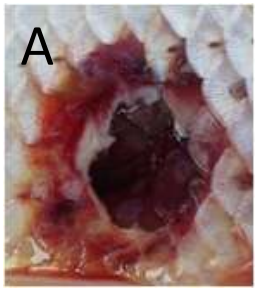
### Otros Consejos:

- Gaste primero el alimento más viejo
- Utilice tarimas para evitar el contacto del alimento con el suelo
- Deje un espacio de 30 cm con las paredes de la bodega
- La construcción de la bodega debe favorecer la circulación del aire

Figura 12: Una bodega

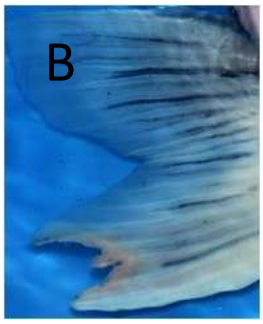
## Cómo Identificar una Trucha Enferma

Las enfermedades son un problema común en el cultivo de las truchas. Algunas indicaciones del comportamiento de que la trucha está enferma son:




- Poco apetito
- Rasguños o frotamiento contra objetos
- Espasmos o convulsiones
- Nada o se mantiene en el agua poco profunda y de poco movimiento.
- Boquea en la superficie del agua (también esto indica falta oxígeno disuelto)
- Natación anormal.
- Respirar anormal.

Cuando se nota el comportamiento anormal, es importante capturar algunos de los peces sospechosos para un examen más detallado. Si en el examen se descubre alguno de los siguientes síntomas, recomendamos **llamar a un veterinario para que le aconseje de tratamiento adecuado**.




- Estómago hinchado o distendido lleno de líquido
- Lesiones abiertos (ver A)
- La falta de la capa de mucosa o piel con una sensación áspera
- Aletas raídas (ver B)
- Branquias pálidas (ver E, derecho saludable, izquierda no saludables)
- Blanco algodón-como crecimientos en cuerpo, cabeza, o aletas (ver C)
- Aspecto azul-gris en la superficie del cuerpo o branquias
- Branquias erosionadas o hinchadas
- Puntos blancos en la cabeza, el cuerpo, y aletas (ver D)
- Algún crecimiento anormal (ver F)




## Uso de Químicos

Para usar cualquier producto químico, es importante saber las condiciones del agua, la salud de las truchas, y el químico en sí mismo. Algunos productos químicos son mencionados abajo. Antes de usar cualquier producto químico en un estanque, **consulte a un profesional**.

### Sulfato de Cobre ($CuSO_4$)

- El sulfato de cobre se utiliza para ajustar la dureza del agua. La dureza del agua puede ser determina usando pruebas disponibles en el comercio. Si la dureza está extremadamente baja, este producto químico puede ser muy tóxico para la trucha.

### Formalina

- La formalina se utiliza para controlar ectoparásitos. También reduce el contenido en oxígeno disuelto. Si se almacena en una temperatura debajo de 4°C convierte al paraformaldehido. Esto aparece como una suspensión lechosa, y es muy tóxico para trucha y no debe ser utilizado.

### Permanganato de Potasio

- El permanganato de potasio se utiliza para levantar el contenido en oxígeno disuelto del agua y para controlar parásitos externos. Cuando está agregado a los estanques, cambia al agua al color morado.

### Oxitetraciclina

- La oxitetraciclina se utiliza para tratar infecciones de bacterias en los peces. Las truchas no deben ser vendidas hasta 21 días después del tratamiento con este químico.

## Cómo Proteger las Truchas en Cultivo de Depredadores

Una red puede ser utilizada para proteger las truchas de los depredadores. La red debe ser asegurada para evitar la entrada de depredadores en los estanques. (Ver la figura 13). Los perros encadenados también ayudan a mantener animales depredadores lejos de los estanques. Los perros deben ser mantenidos lejos de los estanques para prevenir contaminación fecal del agua de estos.

Figura 13: Redes Encima de un Estanque

## Cómo Clasificar las Truchas

Las truchas son peces carnívoros y deben ser seleccionadas por tamaños homogéneos para prevenir el canibalismo. Esto evitará que truchas más grandes se coman las truchas más pequeñas. La selección puede ser hecha manual o utilizando una clasificadora (Ver la figura 14), y se debe realizar en un área del estanque con alto contenido de oxígeno disuelto (entrada del agua).

Figura 14: Una Clasificadora

## Cosecha

Cuando se comercializa la trucha es esencial mantener la calidad adecuada del producto. Asegurar que el producto final, así como el lugar de venta sean limpios y mantenidos apropiadamente es esencial para complacer a los clientes y garantizar su regreso. Registra su información de cosecha en **Anexo C**.

### El Uso de Hielo

El uso de hielo es muy importante en las buenas prácticas de manipulación para asegurar y mantener la calidad. La relación adecuada de hielo: pescado es 1:1, es decir para enfriar un kilo de pescado se requiere un kilogramo de hielo. La cantidad de hielo no es tan importante como la temperatura (ver la figura 15).

| Temperatura | Vida Util |
|---|---|
| 0°C | 5-15 dias |
| 5°C | 2-4 dias |
| 15°C | 1 dia |
| 25°C | 0 dia |

Figura 15: Temperatura y Vida Útil

## Ventajas del Uso de Hielo

1. El hielo posee una gran capacidad de enfriamiento.
2. No contamina, ya que es inocuo, siempre y cuando sea producido bajo estas condiciones.
3. El hielo es relativamente barato.
4. El entrar en contacto directo con el pescado, lo enfría rápidamente.
5. Se puede transportar fácilmente, convirtiéndose en un método de enfriamiento portátil.
6. El agua derretida del hielo mantiene el pescado húmedo, lavado y de apariencia atractiva.

## Fases del Deterioro del Pescado

La trucha una vez que muere, en su organismo se inicia una serie de cambios, que a groso modo se caracterizan de la siguiente manera:

• **Pre-Rigor**- La trucha es blanda y flexible, la textura firme y elástica y el músculo se encuentra relajado (Ver la figura 16).


Figura 16: Pescado en Pre-Rigor

• **Rigor mortis**- El tejido muscular se contrae, el mismo se torna duro y rígido y todo el cuerpo se vuelve inflexible (Ver la figura 17).

Figura 17: Pescado en Rigor-Mortis

• **Post-rigor**- El tejido muscular retorna a su estado relajado, en esta fase la descomposición ocurre más rápidamente (Ver la figura 18).

Figura 18: Pescado en Post-Rigor

Después de ésta última fase del deterioro, inmediatamente se pasa a la fase de deterioro o descomposición del trucha. Mientras la trucha se encuentre en cualquiera de las tres primeras fases: (Pre-rigor, Rigor mortis o Post-rigor), se trata de trucha fresca y por tanto puede ser consumida y no así después de la tercera fase. El secreto es lograr hacer que estas fases se den entre ellas a un tiempo mayor, es decir, retrasar el paso de una a otra. Lo anterior se logra, solamente dando buenas prácticas de manejo al producto y haciendo uso del frío o hielo.

## Evaluación de la Calidad o Frescura del Pescado: Análisis Sensoriales

Existen varios métodos de evaluación de la calidad, sin embargo el más usado y más económico es el análisis sensorial, el cual se detalle (ver la figura 19):

| CARACTER | PESCADO FRESCO | *PESCADO DETERIORADO* |
|---|---|---|
| Piel | Color brillante<br>Mucus transparente | *Decolarada*<br>*Mucus opaco* |
| Ojos | Convexos<br>Transparentes<br>Brillantes | *Cóncavos*<br>*Lechosos*<br>*Opacos* |
| Branquias o Agallas | Rojas<br>Brillantes | *Amarillentas*<br>*Amarronadas* |
| Apariencia muscular | Firme, elástica<br>Color uniforme | *Blanda*<br>*Manchada* |
| Olor Muscular | Fresco olor a mar | *Fuerte mal olor* |
| *Órganos internos* | *Bien definidos*<br>*Olor suave* | *Autorizados*<br>*Olor ácido* |

Figura 19: Análisis Sensorial

## Condiciones Comerciales

En condiciones comerciales, si tenemos que almacenar productos pesqueros, debemos tener en cuenta lo siguiente:

1. Es cierto que el aire frío ayuda a disminuir las temperaturas del pescado, sin embargo se recomienda agregar hielo al producto, antes de ingresarlo a la cámara, ya que de esta forma se previene que el producto no se deshidrate.
2. Cerciórese que la estiba sea realizada adecuadamente. Los productos no deben estar pegados a la pared, ni apilados muy altos, ya que no permiten una circulación de aire adecuada.
3. Los productos no deben estar en contacto directo con el piso. Se recomienda almacenarlos sobre pallets o tarimas de plástico o bien cajas vacías.
4. No junte mariscos con pescados ni menos con filetes de pescados. Si usted va almacenar pescado entero y filetes, preocúpese de que las cajas con filetes siempre estén sobre las cajas con pescado entero, y nunca al revés.
5. Tome en consideración el principio de rotación del producto, es decir primero que entra, primero en salir.

## Requisitos del Puesto de Venta

A) Espacio suficiente para albergar uno o dos vendedores, cajas isotérmicas con pescado, material de trabajo (cuchillos), material de empaque, tableros para cortar.
B) Diseño simple del puesto sin recovecos que dificulten las operaciones de limpieza y desinfección del piso.
C) Instalaciones de agua y desagüe y un lavadero adecuado para lavar el pescado.
D) Lugar iluminado con luz diurna o artificial que permita una buena apreciación del pescado.
E) La superficie de los mostradores de material que fácilmente pueda ser limpiado y desinfectado (acero inoxidable, plásticos de alta densidad, mayólicas de alto grado de dureza en perfectas condiciones, etc.).
F) Pisos con terrazos o locetas con sumideros al colector de desagüe que permitan la eliminación de líquidos después de una operación de limpieza.
G) En caso de tener alguna pared esta deberá ser recubierta por un material lavable y resistente (pinturas epóxicas, etc.) y de color claro.
H) Ubicados en lugares protegidos contra moscas y otros insectos.
I) En caso de existir espacio, se recomienda tener un exhibidor de pescado, que es una especie de mesa o urna que tenga en la parte superior un cajón preferiblemente de metal inoxidable abierto e inclinado donde se coloca el pescado entre una capa gruesa de hielo. Este cajón deberá tener un drenaje para eliminar el hielo fundido y desechos líquidos.

**Para más información, visita al link siguiente, o llama a INCOPESCA.**
**http://www.incopesca.go.cr/Mercadeo/Mercadeo1.htm**

# Información sobre licencias

Las siguientes licencias son necesarias para implementar una finca de cultivo de truchas en Costa Rica. Sin ellas, su granja puede ser susceptible al cierre en cualquier momento.

## La Autorización Para Proyectos Acuícolas

- El artículo ochenta y dos de la Ley de Pesca N º 8436, establece que para desarrollar proyectos de acuicultura , la persona física o jurídica deberá obtener : " Una autorización otorgada por el INCOPESCA para el cultivo de organismos acuáticos en la aguas marinas o en aguas continentales".

## La Viabilidad Ambiental

- El desarrollador del proyecto debe solicitar la viabilidad ambiental ante la Secretaria Técnica Nacional Ambiental (SETENA). Según lo establecido en el decreto Nº31849-MINAE-S-MOPT-MEIC. Denominado, REGLAMENTO SOBRE PROCEDIMIENTOS DE EVALUACION DE IMPACTO AMBIENTAL (EIA).

## La Concesión de uso y aprovechamiento de Agua

- Este trámite se debe realizar ante el Departamento de Aguas del Ministerio de Ambiente Energía y Telecomunicaciones (MINAET). Lo anterior según lo establecido en la Ley General de Aguas Nº 276. El agua es un recurso del estado y se debe pagar un canon por el uso de la misma.

Además se deben de tomar en cuenta otros permisos como:

## El Certificado Veterinario de Operación

- Con la Ley Nº 8495, Ley General del Servicio Nacional de Salud Animal, publicada el 16 de mayo de 2006, en La Gaceta Nº 93, el Servicio Nacional de Salud Animal (SENASA) del Ministerio de Agricultura y Ganadería, se convirtió en el ente gubernamental encargado de velar, entre otros, por la inocuidad de los productos y subproductos de origen animal.

## El Canon de Vertido de Aguas

- Según el decreto Nº 34431. Reglamento del Canon Ambiental de Vertidos es un instrumento económico de regulación ambiental, que se fundamenta en el principio de “quien contamina paga” y que pretende el objetivo social de alcanzar un ambiente sano y ecológicamente equilibrado, de conformidad con lo establecido en el artículo 50 de la Constitución Política, a través del cobro de una contraprestación en dinero, a quienes usen el servicio ambiental de los cuerpos de agua, bien de dominio público, para el transporte, y eliminación de desechos líquidos originados en el vertimiento puntual, los cuales pueden generar efectos nocivos sobre el recurso hídrico, los ecosistemas relacionados, la salud humana y las actividades productivas.

# Información de Contacto

## Información de Contacto de Granjeros de Trucha

| Nombre de Proyecto | Nombre de productor | Teléfono |
|---|---|---|
| **N/A** | Virginia Guillen Vargas | 2538-7127 |
| **La Trucha y El Gavlian** | Roberto Cerdas | 2538-8000 |
| **El Sapito** | N/A | 2534-1818 |
| **Rancho Ursca** | Juan Pablo Torres | 2577-1680 |
| **La Tranquera** | Pedro Nanco Nararro | N/A |
| **Montana de Truchas** | Ouido Chinchilla | 2577-1457 |
| **Truchas la Fuente** | Mariano Chinohilk | 2577-1752 |
| **Trucheros Las Rojas** | Alfredo Rojas Zamora | 2575-0061 |
| **Cipreces Preses** | Jorge Vives | 2551-1848 |
| **Trucha Rancho Grande** | Oliger Arce Gomez | 5000-33-3958 |
| **Truchos Chavolo** | Isaac Rivera Madriz | 1415-2577 |
| **Puerta de Osaca** | Ricardo Vensio Mora | 8373-2426 |
| **Rio Macho** | Oscar Gomez Calderon | N/A |
| **Guarco** | Luis Eladia Tencio Camacho | 8355-5071 |
| **Finca de Rio Macho** | Vidal Camacho Flores | 8868-2359 |
| **Madre Selva** | Alejandro Solano | 2200-0447 |
| **Finca Madre Selva** | Marcos Rojas | 8871-9889 |
| **Mirador de Quetzales** | Leanor Duando Guillen | 2200-5915 |
| **Creador de Truchas** | Oscar Gomez Calderon | 2541-3273 |
| **Truchicultura** | Fernando Guilizon de Churena | 511-30-81 |
| **Trucha Rica** | Cesar Vindes Otarola | 215-41-3323 |
| **El Lago de Pesca** | Mario Prado | 8398-9976 |
| **Lagos los Angeles** | Cepertero Angelo Cerrar | 2907-1307 |
| **Herer Trucha** | Felipe Rivera Chinchilla | 5091-4393 |
| **Pesca la Estrella** | Krispin Fuentes | 2571-1131 |
| **Trucha las Piedras** | Sergio Navarro Arias | 2571-1213 |
| **N/A** | Domimgo Gonzalgi Flores | 2541-3278 |
| **Suyiga** | Gerardo Chaca Suyiga | 2640-1023 |
| **Arco Iris de Los Santos** | Carlos Chacon Zuniga | 2740-1033 |
| **Los Largos Locha** | Mario Mangel Chinchilla | 2740-1038 |
| **N/A** | Flore Lar Raso Cruz | 2740-1003 |
| **Tragon Lodge** | Mauricio Dada | 2740-1051 |
| **Cespesesirian** | Jesus Gonyalo Cespesesirian | 8369-1997 |
| **La Facaya** | Israel Gomez | 8385-2703 |
| **N/A** | Miguel Angel Mena Camaecho | 8828-5550 |
| **Pesca Trucha La Paz** | Porfidio Romero | 8837-1238 |

| | | |
|---|---|---|
| **Elizabet** | Jose Antonio Mora | 2482-2624 |
| **Trucheria Hermanos Salas** | Ronad Salas | 2483-0736 |
| **Las Associacion Anónimo** | Carlos Chacon | 2640-1033 |
| **Centro Turistico San Lorenzo** | Roger Valverde Cerdas | 8366-2821 |
| **Pescada Trucha Carrucha** | Carlos Jimenez | 2445-1940 |
| **Valle Don Jesus** | Guillermo Duran | 2463-1711 |
| **Lagos Cimarron** | Enrique Quesada | 2771-1948 |
| **Trucha Nene** | Freddy Salazar | 2761-1933 |
| **N/A** | Victor Lopez | 2463-2365 |
| **Albergue de Montana** | Dagoberto Torres | 2533-2272 |
| **Truchas Recreativos el Manatiel** | Mario Valladares | 8331-3283 |
| **Montana Trucha de Carchi** | Geraldo Cortez | 2577-1457 |
| **Hotel Quelitales** | Jose Mejias | 2577-2222 |
| **Truchas Chabelo** | Isaac Rivera | 2577-1759 |
| **Rancho Urasca** | Juan Pablo Torres | 2577-1680 |
| **Tragon Lodge** | Issac Quiros | 2740-1051 |
| **Truchas Reales de Costa Rica** | Jose Miguel Viquez | 8376-4253 |
| **Truchero Roble Encino** | Rodolfo Elizondo | 2742-5006 |
| **Pescado Truchas la Paz** | Victor Ramiro | 8837-1238 |
| **Pesca de Trucha la piedra** | Sergio Navarro Arias | 2571-1213 |
| **Centro Turistico de Estrella** | Crespin Fuentes | 2571-1181 |
| **Lagos Santana** | Jose Luis Duran | 2550-1783 |
| **Truchero el Puente** | Enrique Torres | 2770-5532 |
| **Truchero las cocolisos** | Gonzalo Romero | 2742-5023 |

## Información de Contacto de INCOPESCA

| Nombre | Numero |
|---|---|
| **Oficina en San José** | 2248-2387 |
| **Departamento de Acuicultura** | 2248-1196 |
| **Departamento de Mercadeo** | 2239-3883<br>2293-8441 |
| **Centro truchicola Ojo de Agua de Dota** | 2200-5049 |
| **Estación acuícola los Diamantes** | 2763-3293 |
| **Oficina acuícola Ciudad Quesada** | 2460-6110 |
| **Estación acuícola Enrique Jiménez** | 2200-0293 |

## Anexo A: Para Pesar la Trucha

| | Muestra 1 | Muestra 2 | Muestra 3 | Muestra 4 | Muestra 5 |
|---|---|---|---|---|---|
| Numero de trucha en el balde | | | | | |
| Peso de trucha total (Valor C) | | | | | |
| Peso Promedio | | | | | |

## Anexo B: Registra Mensual

| | Enero | Febrero | Marzo | Abril | Mayo | Junio | Julio | Agosto | Septiembre | Octubre | Noviembre | Diciembre |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peso Promedio | | | | | | | | | | | | |
| Trucha por Kilo | | | | | | | | | | | | |
| Biomasa | | | | | | | | | | | | |
| Longitud Media | | | | | | | | | | | | |
| Tasa de Crecimiento Mensual | | | | | | | | | | | | |

## Anexo C: Registra de Cosecha

| | Domingo | Lunes | Martes | Miércoles | Jueves | Viernes | Sábado |
|---|---|---|---|---|---|---|---|
| Número de kilos | | | | | | | |
| Número de trucha | | | | | | | |
| Precio | | | | | | | |
| Destino | | | | | | | |

## Anexo D: Registros Diarios

| Fecha | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Estanque #: | Domingo | | Lunes | | Martes | | Miércoles | | Jueves | | Viernes | | Sábado | |
| ¿Limpiado? | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No |
| | | | | | | | | | | | | | | |
| Mortalidades (Número) | | | | | | | | | | | | | | |
| Cantidad de alimento (kg) | | | | | | | | | | | | | | |
| ¿Observa enfermedades? | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No | Sí | No |
| | | | | | | | | | | | | | | |
| En caso afirmativo, ¿llama a un profesional? | | | | | | | | | | | | | | |
| pH | X | | X | | X | | | | X | | X | | X | |
| Temperatura | Mañana | Tarde | Mañana | Tarde | Mañana | Tarde | Mañana | Tarde | Mañana | Tarde | Mañana | Tarde | Mañana | Tarde |
| | | | | | | | | | | | | | | |
| Observaciones | | | | | | | | | | | | | | |

# Anexo E: Formularios para Licencias

## La Autorización Para Proyectos Acuícolas

## La Viabilidad Ambiental

## La Concesión de uso y aprovechamiento de Agua

## El Certificado Veterinario de Operación

## El Canon de Vertido de Aguas

## Anexo F: Glosario

**Esterilizados:** Limpiar todos los instrumentos, equipo y superficies con el agua y líquido limpiador
**Patógenos:** Unos organismos que causa la enfermedad como bacterias, virus y hongos
**Metabolismo:** Procesamiento de una sustancia (comida, etc.) dentro de un organismo
**pH:** Una medida de la acidez de una solución como el agua, iguale a 7 para soluciones neutras
**Branquial:** Lo que la trucha usa para respirar
**Red de arrastre:** Una red que se usa para obtener las peces en el fondo del estanque
**Alevines:** Truchas jóvenes, menos que 3 cm
**Atarraya:** Una red circular con pequeños pesos distribuidos alrededor de su borde
**Biomasa:** La masa total de organismos vivos en un área particular o volumen
**Aleta caudal:** Las aletas en el extremo de la pez, opuesta de la cabeza
**Monitorear:** Probar en una base regular
**Depredadores:** Un animal que come a otros animales

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